JUNE 1958
AFS CONVENTION REPORT ISSUE

modern castings

Report ON CASTINGS TECHNOLOGY

Report ON THE SHOW

Report ON AFS BUSINESS

PROVED BY INDEPENDENT LABORATORY TESTS:

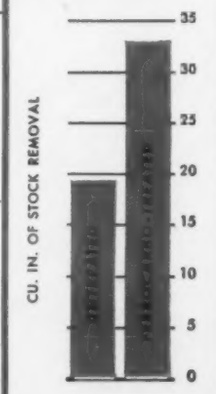
73.8% S•M•I*

for FERROCARBO®-TREATED IRON

These significant test results were obtained by a widely-known independent research laboratory on gray iron automotive castings, including brake drums, gears and transmission housings produced by a large Southern foundry, using untreated and FERROCARBO-treated iron of identical chemistry.

Chemical Analyses	Untreated	Ferrocarbo-® Treated
TC	3.55	3.54
Si	2.42	2.38
Mn	0.91	0.54
S	0.09	0.10
P	0.27	0.25
CE	4.36	4.33
Cutting Speed (ft./min.)	315	315
Feed (in./rev.)	.009	.009
Depth of Cut (in.)	.062	.062
Wear Land (in.)	.010	.010
Vol. of metal removed (cu. in.)	19.4	33.7
Percent improvement		73.8%

STOCK REMOVAL



* Surface Machinability Improvement

Tool wear tests were conducted with a single point "Carboloy" grade 44A tool on castings machined at commercial speeds. Flank wear was measured with a 20 power microscope.

PROGRESSIVE FOUNDRYMEN specify FERROCARBO Briquettes by CARBORUNDUM as a cupola additive because of the assured higher yields of dense, more machinable castings and improved cupola operations. They have found that FERROCARBO deoxidizes iron more completely than any other commercially practicable method and provides a means of producing sound castings at low cost with exceptional strength and hardness properties. Even castings of thin or complicated sections can be produced with absence of segregation, thus increasing the machinability factor of the iron. Numerous critical tests have proved conclusively that FERROCARBO deoxidation means *sound castings in the foundry* and *better machining in the machine shop.*

WRITE FOR MORE INFORMATION on how FERROCARBO produces more machinable iron regardless of metal composition. Ask for booklet A-1409, Electro Minerals Division, The Carborundum Company, Niagara Falls, New York.

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FERROCARBO DISTRIBUTORS—KERCHNER, MARSHALL & COMPANY, *PITTSBURGH • Cleveland • Buffalo • Detroit Philadelphia • Birmingham • Los Angeles • Canada*

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Circle No. 181, Page 7-8

future meetings and exhibits

JUNE

1-6 . . Columbia University, *Industrial Research Conference.* Arden House, Columbia University, New York.

3 . . Metallurgical Associates, Inc., *Sales Clinic.* Sheraton-Syracuse Inn, Syracuse, N. Y.

4-5 . . Magnesium Association, *Symposium.* Aeronautical Sciences Bldg., Los Angeles. *Given jointly with Society of Aircraft Materials and Process Engineers.*

5 . . AFS Division Meetings, Executive and Program & Papers Committees, *Annual Review.* Sherman Hotel, Chicago.

6 . . AFS Technical Council, *Annual Meeting.* Sherman Hotel, Chicago.

9-10 . . Malleable Founders' Society, *Annual Meeting.* The Homestead, Hot Springs, Va.

9-12 . . American Society of Mechanical Engineers, *National Materials Handling Conference.* Public Auditorium, Cleveland. *Held in conjunction with Materials Handling Exposition.*

9-12 . . *Microscopy Symposium.* Del Prado Hotel, Chicago.

9-13 . . *International Automation Exposition & Congress,* Coliseum, New York.

12-13 . . AFS 15th *Annual Chapter Officers Conference.* Hotel Sherman, Chicago.

15-19 . . American Society of Mechanical Engineers, *Semi-annual Meeting.* Statler Hotel, Detroit.

17-20 . . Cornell University, *Industrial Engineering Seminar.* Cornell University, Ithaca, N. Y.

18-28 . . Iron and Steel Institute, *International Meeting.* Belgium and Luxemburg.

19-21 . . AFS 3*d Annual Foundry Instructors Seminar.* Case Institute of Technology, Cleveland.

21-24 . . Alloy Casting Institute, *Annual Meeting.* The Homestead, Hot Springs, Va.

22-27 . . American Society for Testing Materials, *61st Annual Meeting.* Hotel Statler, Boston.

23-25 . . Investment Casting Institute, *Spring Meeting,* Occidental Hotel, Muskegon, Mich.

JULY

21 . . AFS T&RI Trustees, *Annual Meeting.* Union League Club, Chicago.

22-23 . . AFS Finance Committee, *Annual Meeting*. Union League Club, Chicago.

AUGUST

7 . . AFS Executive Committee, *Special Meeting*. Sherman Hotel, Chicago.

7-8 . . AFS Board of Directors, *Annual Meeting*. Sherman Hotel, Chicago.

SEPTEMBER

10-11 . . American Die Casting Institute, *Annual Meeting*. Edgewater Beach Hotel, Chicago.

22-23 . . Steel Founders' Society of America, *Fall Meeting*. The Homestead, Hot Springs, Va.

23-26 . . Association of Iron and Steel Engineers, *Exposition*. Public Auditorium, Cleveland.

29-Oct. 3 . . Association Technique de Fonderie de Belgique, *25th International Foundry Congress*. Brussels and Liege, Belgium.

OCTOBER

6-8 . . National Association of Corrosion Engineers, *Annual Meeting, Northeast Regional Division*. Somerset Hotel, Boston.

8-10 . . Gray Iron Founders' Society, *Annual Meeting*. Sheraton Park Hotel, Washington, D. C.

15-16 . . AFS *Michigan Regional Foundry Conference*. University of Michigan, Ann Arbor, Mich.

16-17 . . AFS *All Canadian Regional Foundry Conference*. Royal Connaught Hotel, Hamilton, Ont.

16-18 . . Foundry Equipment Manufacturers Association, *Annual Meeting*. The Greenbrier, White Sulphur Springs, W. Va.

17-18 . . AFS *New England Regional Foundry Conference*. Massachusetts Institute of Technology, Cambridge, Mass.

27-31 . . American Society for Metals, *National Metals Exposition & Congress*. Public Auditorium, Cleveland.

30-31 . . AFS *Purdue Metals Casting Conference*. Purdue University, Lafayette, Ind.

31-Nov. 1 . . AFS *Northwest Regional Foundry Conference*. Multnomah Hotel, Portland, Ore.

NOVEMBER

10-12 . . Steel Founders' Society of America, *13th Technical & Operating Conference*. Carter Hotel, Cleveland.

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AND MORE OF THEM

at lower cost . . .

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DELTA CORE AND MOLD WASHES

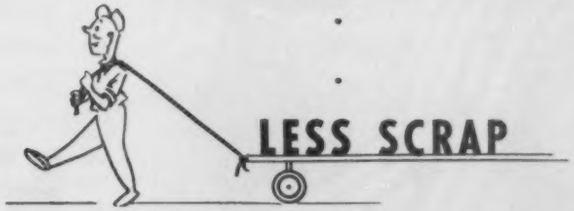
for . . . . . .

CLOSER TOLERANCE

. . . cores and molds have better dimensional stability . . .

LOWER CLEANING ROOM COSTS

. . . surfaces are smooth and require a minimum amount of cleaning . . .



LESS SCRAP

. . . greater number of perfect castings.

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DELTA

ALL DELTA CORE AND MOLD WASHES are easy to apply. After proper mixing they remain in suspension indefinitely. In use, they are non-reactive with molten metal . . . liberate no gases and are highly refractory.

There is a DELTA WASH for every type of metal casting.

DELTA OIL PRODUCTS CORP.

MANUFACTURERS OF SCIENTIFICALLY CONTROLLED FOUNDRY PRODUCTS

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Circle No. 182, Page 7-8

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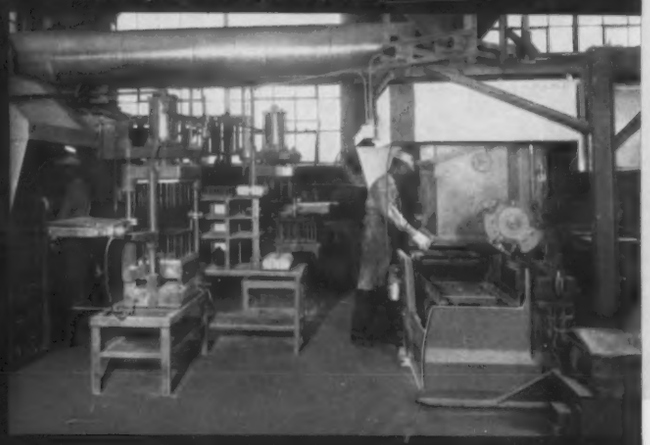
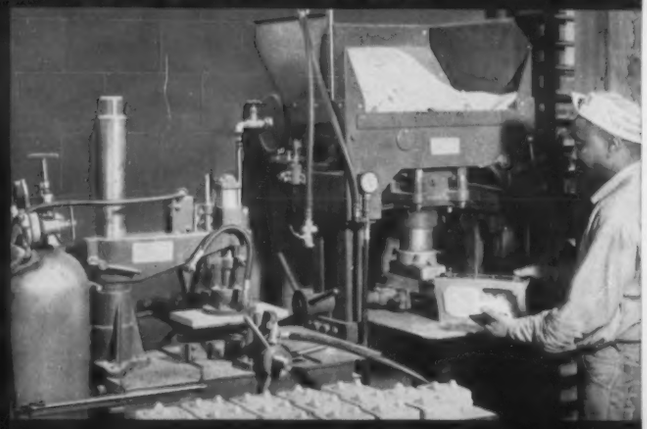
MOLDS—Newest production methods, latest equipment combine to produce high precision, low cost shells on quantity basis.



CORES—Automatic, economical CO_2 shell core-making facilities round out an efficient "mold-a-minute" precision production team.



CASTINGS—Close tolerance, smooth finish, non-ferrous shell-type castings are poured from metal melted in high frequency induction furnaces.

For fast service, fine dimensional accuracy and low over-all cost on small and medium size non-ferrous castings, look to City Pattern Foundry & Machine Company. Here you'll find, too, all the additional facilities . . . a complete, modern pattern shop, foundry, metallurgical laboratory and machine shop . . . that are required to provide an *all inclusive* service on top quality shell process castings.

City Pattern Foundry & Machine Company's experience in the shell process dates back ten years. As a result, here are shell facilities you can count on for all your jobbing needs. We'll be delighted to discuss your needs with you in detail. Why not call or write today.

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AFS Director, A. W. Pirrie, Dies at Castings Congress

■ Alex W. Pirrie, 53, vice-president of manufacturing, American Standard Products (Canada) Ltd., Toronto, Ontario, died May 22 while attending the AFS Castings Congress and Foundry Show in Cleveland. He had presided at the Convention's Canadian Dinner held in the Hotel Cleveland, May 20, and was seated at the speaker's table at annual banquet, May 21.

A. W. Pirrie

Pirrie was elected to the AFS board of directors in 1956, and was formerly chairman, program chairman and director of the AFS Ontario Chapter.

Earns Apprenticeship

Born in Montreal, Quebec, Pirrie served his patternmaker and draftsman apprenticeship at the Canadian National Railways, Montreal, from 1921 to 1927. He then worked as patternmaker for that firm and for the Crane Co., Montreal, advancing to positions of foundry foreman and plant engineer for the Warden King Co., Montreal, in 1937.

Pirrie joined the Gurney Foundry, Montreal, in 1937, working as pattern and design foreman, foundry superintendent and assistant plant superintendent. In 1941, he accepted employment with Electric Steels, Ltd., Three Rivers, Quebec, as master mechanic. He also held the positions of plant superintendent and plant manager for that firm, returning to the Gurney Foundry in 1945 as plant manager.

In 1951 he joined the staff of the company for which he worked at the time of his death, then called Standard Sanitary & Dominion Radiator, Ltd., Toronto. He served as plant manager until 1954; general manager, manufacturing, in 1954; and was named vice-president, manufacturing, in 1955.

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vol. 33, no. 6

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AUDITED PAID CIRCULATION ABC

NATIONAL SAFETY AWARD

To: MODERN CASTINGS
Congratulations!
It is a real pleasure for me to inform you that your magazine has been voted the National Safety Council's Public Interest Award for 1957.
We, here at the Council, have been well aware of all you have been doing for safety, and we are delighted that the judges agreed . . .
. . . I am sure you feel, as we do, that there is another, less tangible result of your safety efforts—the knowledge that you have helped prevent many accidents.
Many thanks for your splendid support.

Sincerely,
Ned H. Dearborn
President

The American Foundrymen's Society is proud to have its magazine, MODERN CASTINGS, receive this national recognition and especially to note that it is the only magazine in the metal-working field to be so honored. This is the third successive year and the fourth time that MODERN CASTINGS has been the recipient of the Public Interest Award.

During 1957 your magazine covered the subject of Safety with four feature articles, two editorials, 26 special short stories, and three columns of "The SHAPe of Things." One of the feature items was a 12-page Bonus Section entitled "Stop Foundry Accidents." MODERN CASTINGS is continuing to dedicate extensive editorial effort in its program of making the metal castings industry constantly aware of the importance of safe practices in their everyday operations.

Modern Castings Editor J. H. Schaum receiving the National Safety Council's Public Interest Award for 1957 from R. O. Blume, president, Des Plaines Chapter of N.S.C.

Most Foundry Noises Can Be Controlled at Source

■ Control foundry noises at their source! This is the best way to tackle the excessive noise problem when such control does not interfere with normal operations.

Noise levels from compressed air exhausts usually exceed design baseline values. Simple mufflers will reduce the loudness effect of this type of noise approximately ten-fold. Air used to blow off molds creates high-frequency noise. Simple silencing devices may be made and attached to the exhaust.

Impact Noise

The noise of castings falling on steel plates, hoppers, stock boxes or conveyors is a familiar source of discomfort in the foundry. The greater the fall, the louder the noise; therefore, decrease the distance that castings must be dropped. If this is impracticable, impact noise may be considerably reduced by laminating steel plates, hoppers, etc.

Wooden and rubber linings are sometimes effective, but are usually not as acceptable as lamination. Rubber linings may "bounce" a small casting, possibly injuring another worker. Wooden linings may splinter and may become oil-soaked, creating a fire hazard. Then too, rapid wear is a primary disadvantage of these two systems.

Tumbling operation for cleaning castings is inherently a noisy one. However, bolting a liner of resitient rubber with steel backing to the inside of tumbler will greatly reduce noise. Experience with this system by a foundry employing 10 liner-equipped tumblers shows little or no wear after one year's service.

Soundproof Booth

The noise generating machine may be enclosed in a soundproof booth, but when this is attempted, care must be taken that excessive heating does not cause damage to bearings and moving parts. Provision for ventilating air may be necessary. Complete enclosure results in considerable noise reduction.

Shakeout noise can, in some cases, be controlled by enclosure. One small foundry has enclosed a shakeout for brass and bronze plumbing fittings with fairly good results. Since the shakeout is continuously fed by conveyor at one end and unloaded by hand at the other, openings are necessary at both ends. These are as small as possible and fitted with curtains of heavy rubberized canvas.

On the pouring floor of the No. 2 Foundry Unit at Sparta, twenty conveyor lines are poured by 3 ladles

At Sparta Foundry—1 million piston rings a day prove the quality of HANNA PIG IRON

Sparta Foundry Company, a division of Muskegon Piston Ring Company, in Sparta, Michigan, can cast up to 1,000,000 piston rings in a single day. Since 1926, it has produced over three billion rings. In castings for piston rings, which will be ground to a close tolerance, Sparta Foundry demands a strong, fine-grained iron with uniform microstructure. For pig iron sure to produce this quality, Sparta Foundry has relied on Hanna for more than 30 years.

Hanna makes all regular grades of pig iron, plus HannaTite and Hanna Silvery. All are available in two sizes—the 38-pound pig and the smaller HannaTen ingot. Your Hanna representative will be glad to tell you more about the advantages of using Hanna pig iron.

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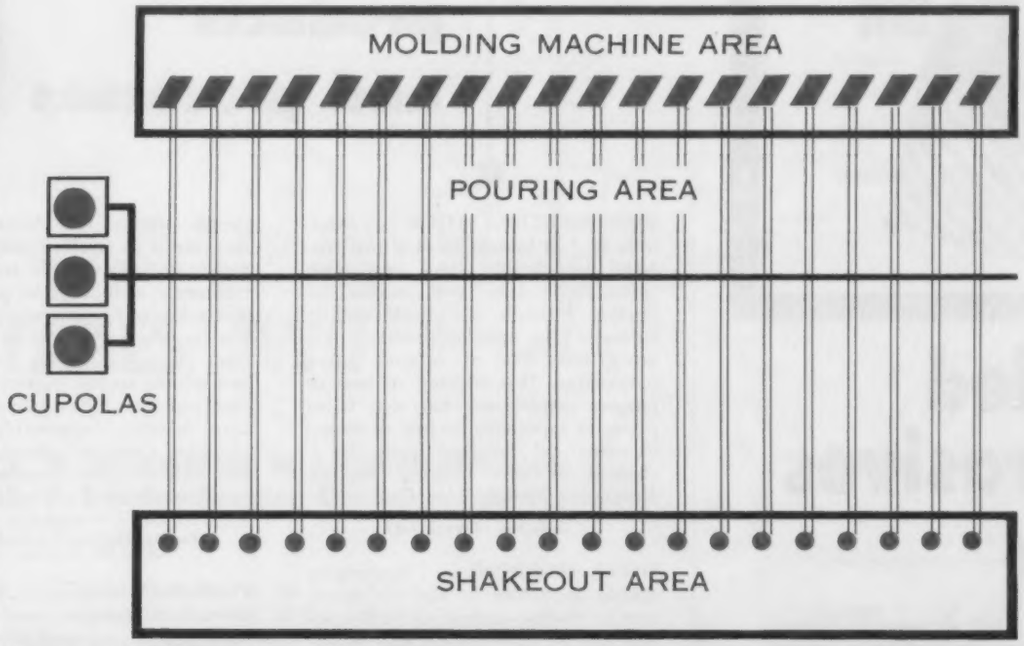
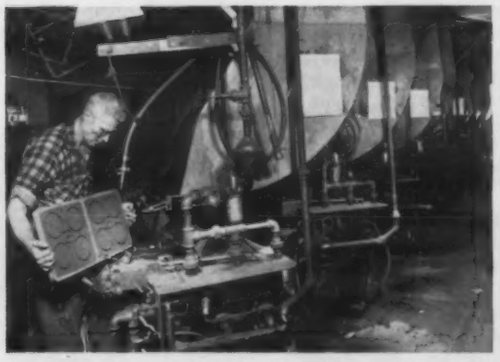
Sparta's operation accents both quality and quantity

This flow chart shows the multiplicity of Sparta's continuous production lines. Twenty molding machines, twenty continuous conveyors, and multiple shakeout stations are part of the operation.





1. *Sparta's No. 2 battery of 20 molding machines. From here, conveyors carry the completed molds to the pouring floor.*

2. *From pouring floor, conveyors take castings to shakeout. After shakeout, piston rings are removed from the "tree."*

THE HANNA FURNACE CORPORATION
Buffalo • Detroit • New York • Philadelphia
Merchant Pig Iron Division of
NATIONAL STEEL CORPORATION

3. *Uniformity and quality are carefully checked in the Sparta laboratories with instruments like this latest Metallograph.*

Circle No. 184, Page 7-8

obituaries

James W. Wolfe, 66, former executive secretary, Non-Ferrous Founders' Society, Inc., Evanston, Ill., died April 29. He had been retired from N.F.F.S. service since 1956, making his home in Cassville, Mo.

Wolfe managed foundries in the Midwest and headed an association prior to joining the N.F.F.S. staff in 1945 as field representative. He tra-

J. W. Wolfe

veled the country strengthening the membership and organizing chapters, and was named secretary-treasurer in 1947. He established the Society's first national office in Chicago.

Stevens H. Hammond, 47, chairman of the board, Whiting Corp., Harvey, Ill., died April 28 in Chino, Calif., where he had moved from Chicago five years ago. He had been associat-

S. H. Hammond

ed with the corporation, which manufactures heavy machinery, since 1923 when he worked as office boy during summer vacations.

He was elected president in 1945 and chairman of the board in 1951. Hammond held a membership in the AFS Chicago Chapter.

better chilled iron abrasives ...and why

We have specialized in the manufacture of metal abrasives since 1888. We have "grown up" with their expanding use. Such long contact with their production and use has given us unequalled know-how and experience in their manufacture.

A continuous program of research for the improvement of metal abrasives has been carried on with one of America's foremost metals research organizations since 1937.

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The two best known names in premium abrasives were developments of two of our subsidiaries. MALLEABRASIVE, the first malleablized type of metal abrasive ever produced, set the pace for development of all other makes of premium abrasives. TRU-STEEL Shot was the first high-carbon all steel shot produced to meet demand for this specialized type of abrasive.

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Arsenal Sta., Pittsburgh 1, Pa.

Subsidiaries: - - -
The Globe Steel Abrasive Co., Mansfield, O. (Malleabrasive)
Steel Shot Producers, Inc., Arsenal Sta., Pittsburgh (Tru-Steel)

Circle No. 185, Page 7-8

Build an idea file for plant improvements. The post-free cards on page 7-8 will bring more information on these new . . .

products and processes

IRON MELTING STOCK . . . available in 3-lb briquettes as a raw material for quality steel production primarily in acid open hearths, induction furnaces and basic electric furnaces. The metallic product is reduced from iron ore at such a low temperature that melting of iron or gangue constituents has not taken place. It reportedly is free of tramp elements and dissolved gases and is claimed to have uniform analysis. *Hoeganaes Sponge Iron Corp.*

For Manufacturer's Information Circle No. 31, Page 7-8

SHELL MOLDING . . . magnesium silicate refractory is said to assure smooth casting surface of steel castings cast by resin-bonded shell molding. Manufacturer claims material inhibits imperfections from gas blow by rapidly chilling surface skin of the metal plus developing sufficient strength to resist outside gas pressure as well as inside ferrostatic pressure. *Harbison-Walker Refractories Co.*

For Manufacturer's Information Circle No. 32, Page 7-8

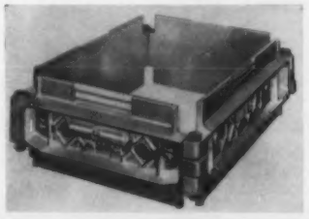
ALUMINUM SOLDER . . . reported to have exceptional wetting properties on both cast and wrought aluminum alloys, and to be tested for corrosion resistance, tensile strength and ease of application. Solder penetrates aluminum oxide when drawn over heated aluminum surface, effecting chemical bond claimed to be stronger than base metal. Officials state that joints last permanently in normal or protected environments, and that galvanic corrosion is not a problem. *United Welding Service Co.*

For Manufacturer's Information Circle No. 33, Page 7-8

FRONT-END LOADER . . . rubber-tired, with rated carrying capacity of 2500 lb, is said to add new capacity and handling ease to front-end loader operation. Power-steering combined with a short turning radius of 6 ft contribute to increased maneuverability; operates in and out of boxcars with 6-ft doors. Power-shift transmission is full-reversing and has two speeds. Offered with choice of gasoline, diesel or liquified petroleum gas power. Interchangeable front-end attachments include pick-up sweepers, hydraulic grab devices, crane hook, tine buckets, scrap buckets and blade snow plows. Triple air cleaning system affords engine protection against dust and dirt. Filtered hydraulic system features replaceable oil-filter cartridge. Company officials state that fuel tank capacity permits full 8-hr operation. Buckets available in several sizes. *Frank G. Hough Co.*

For Manufacturer's Information Circle No. 34, Page 7-8

FLEXIBLE MOLD JACKET . . . claimed to assume exact shape of mold and to automatically adjust to mold taper by means of pivot-pin arrangement at each of four corners. Replacing corner pins with pins of smaller or larger diameter changes fit of mold in relation to parting line.



This feature also permits adjustment of jacket to fit either slip or "pop-off" molds. Cast of aluminum and iron in all sizes. Optional equipment includes filleted corner inserts and steel corner protection shields. *Hines Flask Co.*

For Manufacturer's Information Circle No. 35, Page 7-8

CASTING EPOXY . . . developed especially for making core driers for use in dielectric ovens. Said to eliminate need for expensive driers; easy to cast. *Houghton Laboratories.*

For Manufacturer's Information Circle No. 36, Page 7-8

CO_2 SAND MIXER . . . said to cut mixing time in half. Works equally well with all core binders; will not heat, crush or ball sand. Portable or fixed, unit is easily cleaned. Core sand

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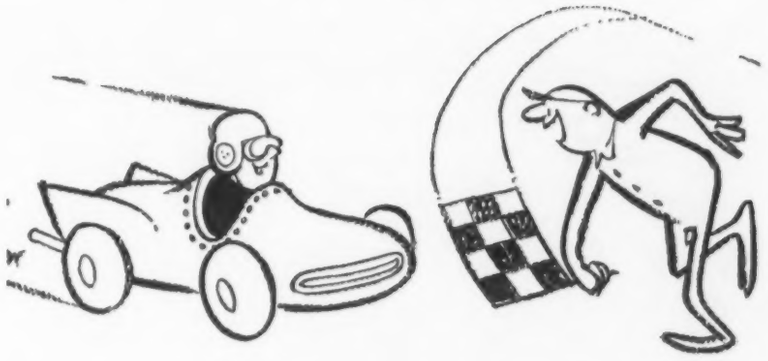


Indianapolis 500 proves it;
Silky Sullivan confirms it:

THE RACE GOES TO THE SWIFTEST

Don't be left at the post—subscribe to **modern castings**

Take the short route around the track—be on the inside and out front by using these **Reader Service Cards**

■ **Details on these products and processes are available to MODERN CASTINGS readers. See page 7-8.**

mixer is one of lowest priced in industry, according to the manufacturer. Model illustrated has 2 cu ft capacity, mixing over 100 lb core sand per load. *U. S. Forge & Foundry Co.*

For Manufacturer's Information Circle No. 37, Page 7-8

HEAVY DUTY FORK TRUCK . . . with working capacity of 30,000 lb at all operating speeds for handling materials in unpaved yard areas and plants. Forks can be hydraulically extended four feet forward at any mast height, and tilt independent of mast 15 deg upward, and 73 deg down.

Attachments include slip-on buckets, scoop buckets, dozer blade and snow thrower. *Pettibone Mulliken Corp.*

For Manufacturer's Information Circle No. 38, Page 7-8

COLD COATING RESIN . . . claimed by manufacturer to combine medium curing speed, superior warp resistance and high dimensional stability in cold coating of sand for shell cores and contour shell molds. Officials state resin imparts high strength characteristics with good shakeout properties. *Archer-Daniels-Midland Co., Federal Foundry Supply Div.*

For Manufacturer's Information Circle No. 39, Page 7-8

CHEMICAL JOINING . . . of nonferrous metals made by permanent chemical bond through ion exchange. New material is said to reduce present joining costs 50-300 per cent. May be used in manual or mechanized operations. *Intertectics, Inc.*

For Manufacturer's Information Circle No. 40, Page 7-8

SUPER PURE ALUMINUM . . . available in ingot form. Purity of 99 per cent may be obtained in 6, 15, 30 and 50-lb sizes. This product has not been generally available to in-

Circle No. 186, Page 7-8

WIN YOUR CHOICE IN NEW PANGBORN CONTEST

Celebrating the successful introduction of new

Pangborn Rotoblast® Steel Shot

FOLLOW THESE SIMPLE RULES:

1. Anyone employed by a company using blast cleaning equipment is eligible for this contest, except employees of Pangborn Corporation, its agencies or affiliates.
2. Check Rotoblast Steel Shot ad in this issue for answers and fill in missing words on the Official Entry Blank.
3. Sign your entry and mail to Pangborn Corporation, Hagerstown, Md. Entries must be postmarked not later than the 4th of July, 1958.
4. All entries with correct answers will be deposited in a container from which the lucky winner will be drawn and awarded his choice of Ford Thunderbird, Chevrolet Corvette or Plymouth Fury.

OFFICIAL ENTRY BLANK

PANGBORN CORPORATION, Hagerstown 13, Maryland

In new ROTOBLAST STEEL SHOT, voids and defects are virtually eliminated by a new shot manufacturing process called _____ Casting.

Continuous heat treating in a controlled atmosphere gives you _____ hardness and _____ life. Result: faster cleaning and lowest blast cleaning costs ever.

Name..... Title.....

Company.....

Address.....

City..... Zone..... State.....

Famous CORNELL CUPOLA FLUX

In the last analysis it's cleaner metal that's the pay off!
Famous **CORNELL** **CUPOLA FLUX** *will give you the cleaner metal you want*

often imitated
but never equalled!

Have you tried Famous Cornell Aluminum or Brass Flux? Write for Bulletin 46-A

The CLEVELAND FLUX Company
1026-40 MAIN AVENUE, N. W. • CLEVELAND 13, OHIO
Manufacturers of Iron, Semi-Steel, Malleable, Brass, Bronze, Aluminum and Ladle Fluxes—Since 1918

FAMOUS CORNELL FLUXES
Trade Mark Registered

Circle No. 187, Page 7-8

dustry in ingot form. *Kaiser Aluminum & Chemical Sales, Inc.*

For Manufacturer's Information Circle No. 41, Page 7-8

MOTORS FOR OUTDOOR OPERATION . . . under extreme weather conditions such as high winds, driving rain, snow, sleet, and sandstorms; said to prevent entrance of windborne particles and moisture by abruptly changing direction and slowing velocity of incoming airstream. Features moisture and chemical resistant insulation and inspection ports for observing oil rings while motor is operating. *Louis Allis Co.*

For Manufacturer's Information Circle No. 42, Page 7-8

BOLT-ANCHORING CEMENT . . . sets in 10 min. Bolts, according to manufacturer, can be drawn tight and light machinery put in operation within a half hour; heavy equipment, one hour. The company reports that this improved product has a strength 10 times that of ordinary powder or holding cement while expansion factor has remained comparable. Mixes with water to form semi-fluid, easily-poured compound. *Monroe Co.*

For Manufacturer's Information Circle No. 43, Page 7-8

GATE TILES . . . with matching tees and elbows claimed to withstand temperatures involved in pouring steel castings. Tests substantiate effectiveness in preventing erosion of gates. The hard, dense-surfaced tiles are available in sizes ranging from 3/4 to 3-1/2 in. inside dia, and in all popular lengths. Standard size tees and elbows fit 1-1/2 to 3-in. tile. *Louthan Mfg. Co.*

For Manufacturer's Information Circle No. 44, Page 7-8

NEW METAL ABRASIVE . . . claimed to compare favorably with regular steel shot in performance, but to sell at a price approximating malleable shot. Cleaning costs are lower than that of other abrasives, manufacturer claims. Manufactured as shot and grit to S.A.E. specifications, available in 50 and 100-lb bags. Free laboratory tests offered, or sample will be sent on request. *Metal Blast, Inc.*

For Manufacturer's Information Circle No. 45, Page 7-8

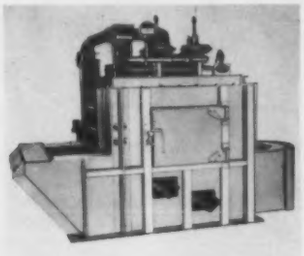
PROTECTIVE FLOOR ENAMEL . . . for use on volume-traffic wood and concrete floors contains synthetic resin base reputed to withstand scuffing, pounding and abrasive action of heaviest foot traffic. Claimed to prevent dusting of concrete floors and dirt accumulation in porous wood floors. Manufacturer states enamel resists oils, greases, solvents and mild industrial acids, and is unaffected by strong caustic cleansers and heavy-

■ Details on these products and processes are available to MODERN CASTINGS readers. See page 7-8.

duty floor-cleaning machines. Available in five colors, dries overnight. *Garland Co.*

For Manufacturer's Information Circle No. 46, Page 7-8

MELTING-HOLDING FURNACES . . . may be used for die casting, permanent mold casting and sand casting. Manufacturer claims return scrap may be charged back on sloping hearth, eliminating contamination of furnace with inserts. Fully automatic



furnace contains bridged, ladle-out well. Radiant roof heating reduces melt loss. Available in 1200-5000-lb capacities of aluminum. *Sunbeam Corp., Industrial Furnace Div.*

For Manufacturer's Information Circle No. 47, Page 7-8

SAND RAMMING TIPS . . . and liners offer a combination of impact strength, abrasion resistance and hardness which manufacturer states cuts sand slinger operating costs. Tips and liners employ a new alloy steel guaranteed to provide the lowest cost per ton of sand rammed. *Beardsley & Piper Div., Pettibone Mulliken Corp.*

For Manufacturer's Information Circle No. 48, Page 7-8

VERSATILE GAGE . . . sets angles, locates centers and levels surfaces, reportedly combining three basic machinist's tools in one; angle gage, centering-head and level. Manufacturer claims this tool does the work up to 600 per cent faster, leaving both hands free for adjusting. Useful in leveling machinery, grinding and welding. *Brite-Line Corp.*

For Manufacturer's Information Circle No. 49, Page 7-8

COMPRESSED AIR PURIFIER . . . is claimed to result in more complete removal of water, oil, pipe scale, rust and sediment from compressed air, steam or vapor lines. Useful in delivering clean compressed air for

Circle No. 188, Page 7-8

You have never used abrasive like this new

ROTOBLAST® STEEL SHOT

1 Vacuum Casting

Electric furnace alloy steel, shotted in revolutionary new vacuum chamber for greater density, eliminating the voids and defects encountered in conventional steel shot. Gives you a fatigue resisting shot of much longer wear life.

2 Continuous Heat Treating in Controlled Atmosphere

Nothing like it in the industry. Uniform heating of every particle, in zero oxygen atmosphere. For the first time . . . ball bearing heat treating quality in a tonnage product . . . gives you uniform hardness and longer life.

New Rotoblast Steel Shot gives you much faster cleaning and the lowest blast cleaning cost ever!

Schedule an early test! Talk to the Pangborn Engineer in your area or write PANGBORN CORP., 1300 Pangborn Blvd., Hagerstown, Md.

Pangborn

Rotoblast Steel Shot

molding and sand blast machines, air drills, etc. No moving parts to get out of order or require adjustment or maintenance.

Company guarantees removal of 99 per cent of all entrainment when properly installed. Built to give non-shock service for steam up to 400 psi, 650 F; and for compressed air up to 800 psi and 100 F. *Centrifix Corp.*

For Manufacturer's Information Circle No. 50, Page 7-8

NEW FRONT-END LOADER . . . said to offer exceptional maneuverability, easy operation, and good versatility for intra-plant bulk materials

handling. Rated payload capacity, 19 cu ft; struck capacity of the bucket, 14 cu ft; and maximum lifting load, 3000 lb. Foot-brake operates an "inching" valve, permitting easing into the restricted areas. Speeds range up to 11 mph forward or reverse. Average over-all operating height, averages 6 ft, 9 in. *Euclid Div., General Motors Corp.*

For Manufacturer's Information Circle No. 51, Page 7-8

HOT SAND COOLING . . . unit cools sand by mixing moisture additions with shakeout sand continuously on conveyor belt, drawing off heat through top exhaust while thoroughly blending and fluffing sand. Manufacturer claims 200 F sand is reduced

to 140 F at discharge of unit with additional cooling in transit by direct transfer of heat to air. All capacities available; can be mounted, completely assembled, on conveyor belt without alterations. *Pekay Machine & Engineering Co.*

For Manufacturer's Information Circle No. 52, Page 7-8

THE NEW HERMAN

Moldmaster

Another revolutionary machine developed to meet the normal molding requirements of most foundries.

The flexibility of the jolt, squeeze, strip machine, makes it readily adaptable to a wide variety of molding applications, as illustrated.

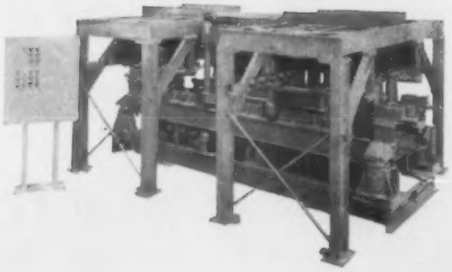
The Herman Moldmaster fits into four different methods of operation. It is designed to operate by automatic, semi-automatic or push-button controls.

The Moldmaster has the exclusive Herman feature of self-adjusting squeeze head attached to the jolt machine. This contours the squeeze head for any shape of pattern. Jolt squeeze action is simultaneous.

Sand flows in such a manner as to insure a perfect mold. Wear on the Moldmaster as well as the pattern equipment, is practically eliminated. Mold hardness can be increased or decreased at any point.

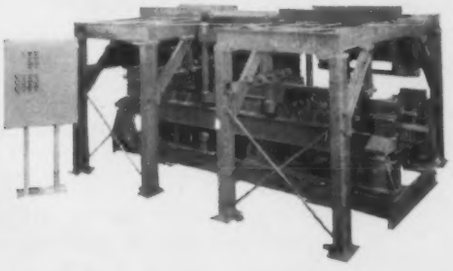
For more detail on the many outstanding features of this machine, ask for our Technical Bulletin No. JSS-5-58.

Circle No. 189, Page 7-8

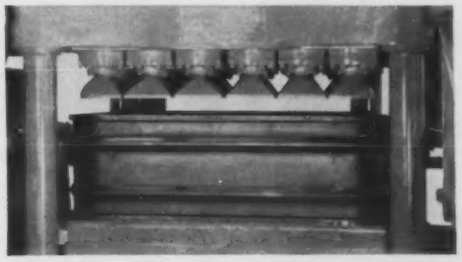


1 The mold has been simultaneously jolt squeezed, rammed, and returned to the stripper station. The mold has been stripped and is in position to be discharged.

2 The mold has been discharged and the incoming empty flask has automatically been positioned and lowered onto the pattern to be moved to the ramming station.



3 The empty flask which had been placed on the pattern is now in position at the jolt squeeze station. The flask had been filled automatically and struck off while moving from the stripper station.



4 The mold has been simultaneously jolted and squeezed. Self-adjusting squeeze heads have been retracted and the mold is ready to be moved to the stripper station.

HERMAN PNEUMATIC MACHINE CO., UNION BANK BUILDING, PITTSBURGH 22, PA.

MEMBER FEMA FOUNDRY EQUIPMENT MANUFACTURERS ASSOCIATION INC.

HERMAN

Best Known Name in Molding Machines

Circle No. 189, Page 7-S

product reports

1200 F hot blast

. . . preheater for new cupola installation at James B. Clow & Sons, Coshocton, Ohio, is reported to be capable of cutting coke consumption from 20 to 30 per cent. Manufactured by Brown Thermal Development Co., Elyria, Ohio, this all metallic hot blast preheater leads to other cupola operation advantages such as: 1) better temperature control, 2) reduced silicon oxidation losses, 3) improved sulphur control, 4) elimination of bridging, 5) reduced cupola refractory burnout, and 6) increased metal production.

Finned combustion tubes account for better heat transfer with smaller heaters. With less coke required for the bed, iron is said to be produced with as low as 0.01 per cent sulphur. Since unit can deliver an instantaneous supply of hot blast, melting is speeded and hotter iron is available.

For Manufacturer's Information Circle No. 53, Page 7-S

Core car lubricant

. . . withstands temperatures over 400 F and saves C. H. Milles Foundry Co., Chicago, 80 man-hours of labor annually. Core cars, loaded with 2-1/2 tons of sand cores, stay in the oven at 400 F for 5 hr every day.

Before switching to their new lubricant Oildag—a dispersion of colloidal graphite in petroleum oil, Milles Foundry used conventional high-temperature grease. Every month the wheel and bearing assemblies had to be torn down to free "frozen" bearings and clean off heat-polymerized grease. Since switching to graphite

Only fine **FANNER**

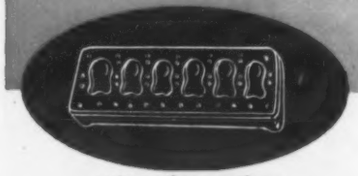
shoulder radiator chaplets

have the exclusive

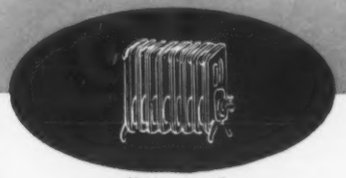
4 way **break-off nick**

to improve production... save money

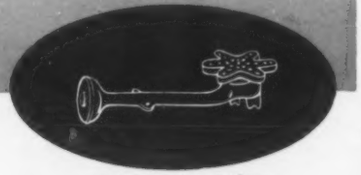
IDEALLY SUITED FOR



automotive castings



radiator castings



stove parts castings

EXCLUSIVE *New* 4-WAY BREAKOFF NICK

Provides maximum support during pouring, yet stem breaks off easily in any direction so that the few remaining after shake-out can be easily brushed off with no apparent surface marks remaining.

STAGGERED KNITTING NICKS

Provides better type of surface for knitting with molten metal, assuring thorough fusion and resulting in clean, solid castings.

STURDY SHOULDER AND SOLID RIVETED HEAD

Shoulder is designed and placed to permit chaplet to be set into pattern required distance without guesswork. Solid riveted head exactly at right angles to stem to insure that chaplet is always perfectly "true".

For better quality castings, for time and money savings in production use fine FANNER radiator chaplets. The exclusive four way break-off nick plus their other features speeds production of cleaner, sounder castings and reduces labor costs.

The development of the 4 way break-off nick is one more example of Fanner's constant study and engineering based on more than 60 years of experience in foundry practice.

Fine FANNER Radiator Chaplets are particularly suited for light pressure castings such as gas burners, radiator sections, manifolds and others. They are designed for use with the side of the greatest bearing surface against the green sand and will support approximately 5 pounds per square inch load.

Get complete information on FANNER Radiator Chaplets with the "4 way break-off nick" and other fine FANNER chaplets by writing for the FANNER Chaplet catalog today!

Qualified and specialized engineers in Fanner's Technical Service Division are available for consultation, without obligation, on problems of producing more intricate castings; developing increased strength, closer tolerances, and better quality; reducing machining and improving finish — both in ferrous and non-ferrous castings. Take advantage of the research and development work that Fanner has invested in this field to improve your profit picture! Simply direct your request to the address shown below.

THE FANNER MANUFACTURING CO.

Designers and Manufacturers of Fine Fanner Chaplets and Chills

BROOKSIDE PARK • CLEVELAND 9, OHIO

Circle No. 190, Page 7-8

■ Details on these products and processes are available to MODERN CASTINGS readers. See page 7-8.

lubrication this cleaning job is done only once every 10 months.

According to Ray Wagner, shop superintendent, they mix one gallon of Oildag (Acheson Colloids Co.) with 30 gallons of No. 30 Famous

Pale oil (Famous Lubricants Inc.) and apply it with a liquid Zerk gun through Zerk fittings on the bearings each day.

For Manufacturer's Information Circle No. 54, Page 7-8

Mass-Production Missiles Will Use More Aluminum

■ More and more aluminum will go into future guided missiles. A recent study by Kaiser Aluminum & Chemical Corp., Oakland, Calif., reports that practically every part of a missile and most components in the support systems can be built of aluminum.

Three factors favor the increased use of aluminum, as compared with present-day missiles:

1) Increased efficiency will depend on lowering non-payload weight; one lb saved is equal to a gain of 1800 ft in altitude or a mile of range.

2) As missiles pass into the mass production stage, cost increases in importance. Other factors being equal, aluminum has an advantage over most other suitable materials.

3) Only aluminum is now available in sufficient quantity to support mass production of missiles.

It has been suggested that better high-temperature metals are required because portions of some missiles may rise to very high temperatures during periods of exposure to air friction. The Kaiser study concludes that because such temperatures are beyond the capabilities of any metals, it seems likely that a solution where required will be found by redesigning flight paths and through skin-cooling devices.

Circle No. 191, Page 7-8

A PARTIAL LIST OF Knight CLIENTS FOR PROFESSIONAL FOUNDRY ENGINEERING

- **Acindar, S.A.**
  Buenos Aires, Argentina
- **Acinfer, S.A.**
  Villa Constitucion, Argentina
- **Alloy Steel Products Co.**
  Linden, N. J.
- **American Brake Shoe Company**
  Chicago and St. Louis
  Buffalo and New York
- **American Radiator & Standard Sanitary Corp.**
  Baltimore and Louisville
- **Appleton Electric Company**
  South Milwaukee, Wisc.
- **Belle City Malleable Iron Company**
  Racine, Wisc.
- **Buckeye Steel Foundry Co.**
  Columbus, Ohio
- **Buderus 'sche Eisenwerke**
  Essen, Germany
- **Canadian Car and Foundry Company, Ltd.**
  Montreal, Quebec
- **Chrysler Corp.**
  New Orleans, La.
- **C. K. D.**
  Blansko, Czechoslovakia
- **James B. Clow & Sons Co.**
  Birmingham, Ala.
- **Combustion Engineering, Inc.**
  Chattanooga, Tenn.
- **Crane Co.**
  Chicago and Chattanooga
- **Dalton Foundries, Inc.**
  Warsaw, Ind.
- **Dayton Malleable Iron Co. (3 plants)**
  Dayton, O.
- **Der Stahl- und Temperguss A. G.**
  Traisen, Austria
- **Electric Steel Foundry Company**
  Portland, Ore.
- **Erie Malleable Iron Company**
  Erie, Pa.
- **Fahralloy Canada Limited**
  Orillia, Ont.
- **Fairbanks, Morse & Co.**
  Kansas City, Kan.
- **Federal Malleable Co.**
  Milwaukee, Wisc.
- **General Steel Castings Corp.**
  Eddystone, Pa.
- **Goetzewerke A/G**
  Burscheid, Germany
- **Hammond Brass Works**
  Hammond, Ind.
- **Haynes Stellite Company**
  Kokomo, Ind.
- **Moline Malleable Iron Company**
  St. Charles, Ill.
- **Mueller Co.**
  Decatur, Ill.
- **National Roll & Steel Foundry Co.**
  Avonmore, Pa.
- **Ohio Injector Co.**
  Wadsworth, Ohio
- **Pittsburgh Steel Foundry Corporation**
  Glassport, Pa.
- **Sibley Machine & Foundry Corporation**
  South Bend, Ind.
- **Spojene Tovarny Na Obrabeci Stroje**
  Brno, Czechoslovakia
- **Stavanger Electro-Staalverk A/S**
  Jorpeland, Norway
- **Stockey & Schmitz**
  Gevelsberg, Germany
- **Stockham Valves & Fittings**
  Birmingham, Ala.
- **Sulzer Bros. Ltd.**
  Winterthur, Switzerland
- **Superior Steel & Malleable Castings Co.**
  Benton Harbor, Mich.
- **Universal Castings Corporation**
  Chicago, Ill.
- **Wagner Malleable Iron Company**
  Decatur, Ill.
- **Walworth Company**
  Kewanee, Ill. and Boston, Mass.
- **Woodruff & Edwards, Inc.**
  Elgin, Ill.
- **Worthington Corporation**
  Harrison, N. J.

Lester B. Knight & Associates, Inc. has successfully

ranging

layout,

Foundry Mechanization

The degree and type of mechanization should be established for each requirement. The simplest unit of rugged design and construction to insure minimum maintenance is a must. Over-mechanization should be avoided.

Automation

Automation can and must be applied in foundries to the degree justified by the particular problem. Knight engineered the first fully automated unit producing 272 molds per hour, 16 hours per day. Many other operations have been established on semi and fully automated cycles. Each problem is a study in itself to establish its economic justification.

Materials Handling

By proper plant layout and handling methods, manual handling has been reduced to a minimum. The ideal, of course, is to perform an operation on the material each time it is handled. In the foundry from 100 to 400 tons of material are handled to ship 1 ton of castings.

Foundry Management

Knight has reorganized, refinanced and operated foundry businesses successfully and has temporarily directed operations in one or more departments for short periods to establish low cost operations.

Foundry Organization

Knight has established simple organization programs pinpointing responsibility and authority, providing proper communication between various functions and, of course, providing complete administrative and procedure manuals to make certain that all personnel are familiar with policies and each knows and understands his job.

Foundry Engineering

Complete surveys of plants to establish the basic requirements for modern, low-cost operation. Knight Engineers become, temporarily, a part of the client's organization to make a comprehensive, objective analysis and, with the client's staff, develop the most modern methods and facilities. The result of the combined effort always is a better solution than either group could develop separately.

Architectural Engineering

Undivided responsibility, from drawing board to completed plant, has insured savings in time and money. Knight experience has helped to improve working conditions in a simple, functional plant designed for foundry operation. Knight has a complete and experienced mechanical, electrical, structural and architectural staff who have supervised the design of hundreds of millions of dollars of industrial plants.

completed more than 350 foundry engineering assignments . . .

from the solution of a single problem in one department to the design and supervision of construction of complete new plants.

In many instances, we have assisted the client to modernize methods and facilities, then established the new organization and procedures for adequate control (including cost control), and new incentives based on the work content of the job.

Construction Management

After plans have been approved, Knight has acted as the client's representative to supervise construction at minimum cost. This service has included supervision of "cost-plus" as well as fixed price contracts. The saving in time and money is far greater than the cost of complete construction management service.

Foundry Modernization

Modern methods, facilities, controls, sales methods, rigging and operating techniques can and must be used by all sizes and types of foundries to insure low cost, profitable operations with high take home pay, low unit costs and adequate return to management and owners.

Industrial Engineering

These services have included establishment of standards for incentive wage payment plans to insure a full day's work for a full day's pay, labor contract negotiations, establishment of basic data for estimating, cost and labor control, preventive maintenance programs and plant layout, protection and service.

Methods

Knight engineers have completed analyses of methods to reduce time and motion to a minimum and to establish the most efficient rigging to permit full utilization of existing personnel and equipment. A method study should always be tied in with establishment of incentive wage plans.

Cost Controls & Budgets

The Knight organization has installed cost systems in more than 100 manufacturing plants, including foundries, to establish better and simple controls, "highlight" inefficiencies and establish budget goals for all levels of supervision and management. Every foundry must know its costs to insure continued profitable operation, competitively. A periodic review or audit by Knight Engineers insures that this "tool" of management is kept up to date.

Production Control

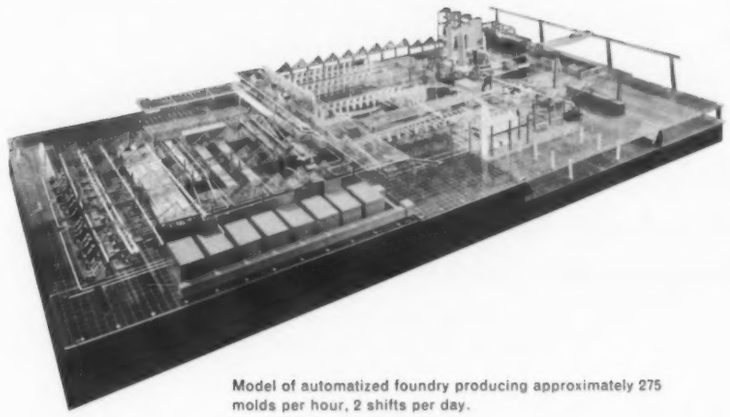
Delivery promises always are important and sometimes critical. Systematic production scheduling and control based on known factors requires a minimum of people and insures a minimum of missed shipping dates.

Surveys

Knight-engineered audits of operations can assist you to establish the changes necessary to secure maximum utilization of facilities and manpower—and thus maintain the most efficient, low-cost operation.

Marketing

Knight has surveyed markets to establish the availability of work suitable for a particular foundry and to determine the type of facilities to be established for the available work.



Model of automatized foundry producing approximately 275 molds per hour, 2 shifts per day.

Knight Organization

The key men in Lester B. Knight & Associates, Inc. have from 10 to 25 or more years of successful experience in some phase of foundry management, production, engineering or equipment. The coordination of each man's specialized experience enables the Knight organization to give foundry management reliable, practical assistance on virtually all foundry problems.

The Knight organization has completed more than 350 successful assignments in every type of foundry—grey iron, steel, malleable, brass and bronze, magnesium, and aluminum. These foundries are producing castings from a few ounces to 50 tons and from 1 to more than 1,500 tons of castings per day. Green sand, dry sand, cement, plaster, "shell" molds, permanent mold, centrifugal, die casting and investment casting operations all have been served by Knight.

Working closely with clients' staffs, Knight Engineers have assisted its clients to audit operations, define management functions, establish organization, modernize methods and facilities, and design complete new plants. They have successfully applied automation in varying degrees to a number of different types of foundries, and have assisted management to establish more economical procedures for the control of operations and costs.

Lester B. Knight & Associates, Inc.

Management, Industrial and Plant Engineers

Member of the Association of Consulting Management Engineers, Inc.
549 W. Randolph St., Chicago 6, Ill.
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New York Office—Lester B. Knight & Associates, 375 Fifth Ave., New York City 16
Knight Engineering Establishment (Vaduz), Zurich Branch, Bahnhofstrasse 17, Zurich, Switzerland

High Temperature Alloy for Jet Engine Turbine Blades

■ A new "predesigned" alloy which is said to exhibit outstanding strength at the high operating temperatures found in rockets, missiles and jet aircraft, has recently been developed by Westinghouse Electric Corp., Pittsburgh, Pa.

The alloy, known as Nicrotung, is expected to raise the operating temperatures of jet engine blades to 1800 F. This is a temperature boost of about 150 F over present-day engines. According to Westinghouse officials this is about equal to the total increase in operating temperatures made in such engines over the past five years.

Sets Temperature Ceiling

A company spokesman declares, "Because of the high temperatures to which they are exposed and the terrific stresses they undergo at these temperatures, turbine blades set the temperature ceiling for turbojet engine operation. Improved blade materials, combining better strength at ever higher temperatures, are essential to continued improvement in engine performance. Nicrotung is believed to be a step toward such improvement."

The new alloy gets its name from three of the essential metals that compose it: nickel, chromium and tungsten. Properties include improved castability, oxidation resistance, stress-rupture strength and ductility.

Nickel Base

Nickel was chosen as the base element in the design of the material because, officials state, it is the most practical high melting point element available at the present time for 1800 F service. Chromium was added to give oxidation resistance, after which tungsten was added in order to confer hardening.

The new alloy reportedly withstands a stress of 32,000 lb per sq in. at 1700 F for as long as 100 hr without failure. At 1800 F, the alloy withstands a stress of 22,000 lb per sq in. for this length of time.

The product is undergoing exhaustive tests at the company's aviation gas turbine division in Kansas City, where it is being evaluated for use in Westinghouse jet aircraft and missile engines.

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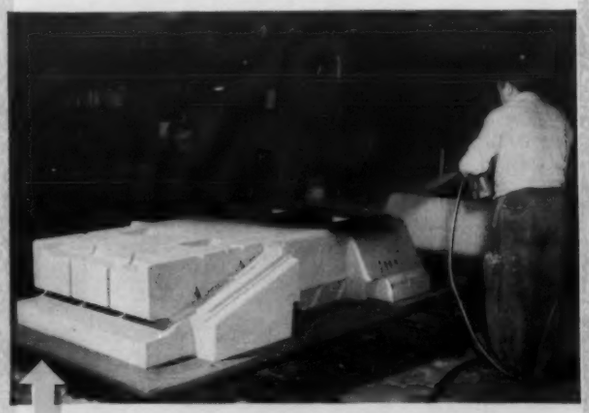
Circle No. 192, Page 7-8

HILL-ACME
reports on value of...

John Makren and Joe Zargel, coremakers at Hill-Acme are stripping the box from a 3000-lb. LIN-O-SET core which is typical of much of the core work in this modern foundry. Two of these giants form the core assembly for a 3½-ton machine tool base pan casting. Note the delicate undercut on the left side of the core, which involved considerable time and trouble prior to the use of LIN-O-SET.

Otto Spirek, plant superintendent at Hill-Acme, discusses mixing procedures with Dan Chester, ADM Technical Service Mgr., who makes periodic checks on procedures, and stands ready to apply his specialized knowledge to core problems as they arise.



Hill-Acme castings are known for their excellent finish. They attribute this to high density of LIN-O-SET cores, and the use of FEDERAL No. 801 PLUMBAGO COREWASH. Illustration shows Paul Colella spraying on FEDERAL No. 801.

LIN·O·SET

½ the fabricating time
½ the baking time

...and vastly improved casting finish. These are the primary reasons why HILL-ACME COMPANY of Cleveland, Ohio, switched from conventional core oil to LIN-O-SET.

Larry Rayel, ADM Representative, suggested that Hill-Acme try LIN-O-SET as an experiment. The huge, complicated cores presented constant problems: for instance, they had to use back-up sand to reinforce delicate undercuts; it was difficult to hold dimensional stability and at the same time attain sufficient flowability for easy ramming; they had to "baby" green cores due to their extreme size and weight; then the large cores had to bake for two nights.

After a demonstration by ADM Technical Service Manager, Dan Chester, it was decided to put LIN-O-SET into the entire core operation.

Now, a year later, these are the recognized benefits: after a short air-curing period, core boxes are stripped faster and easier without danger to the core, and the core has absolutely no sag after stripping; there is less need for rodding; high green strength of the cores as drawn permits safer handling, reducing green core breakage; minimum ramming and tucking are required due to low green strength and high flowability of LIN-O-SET sand as discharged from the muller. All in all, total fabrication time for LIN-O-SET cores is estimated to be at least 50% less.

Baking time was reduced from two nights to one night. Excellent collapsibility of the cores reduces cleaning to a minimum.

Perhaps a demonstration of LIN-O-SET in your foundry will bring about attractive savings for you. Write for LIN-O-SET technical bulletin.

Archer QUALITY

Archer-Daniels-Midland company

FEDERAL FOUNDRY SUPPLY DIVISION

2191 West 110th Street • Cleveland 2, Ohio

Aim toward better castings through the use of Archer Quality Supplies:

GREEN BOND H-J High-gelatinating Bentonite	**FEDERAL** Sand Stabilizer	**LINOIL** Core Oils	**ADMIREZ** Foundry Resins
GREEN BOND L-J Low-gelatinating Bentonite	**FEDERAL** Core Washes	**INDUCTOL** Fast-baking Core Oils	**ADCOSIL** CO_2 Binders
CROWN HILL Sea Coal	**FEDERAL** Plumbagos	**LIN-O-SET** Air-setting Core Binders	**LIN-O-CEL** Sand Stabilizer
	FEDERAL Core Pastes		**FRE-FLO** Parting Compound

Introducing...

4.50 GRAMS

ACTUAL SIZE

The New Look in

LITHIUM COPPER CARTRIDGES

Lithium isn't new to foundrymen. But the new, improved, 4.50 gram cartridge is. Thinner walls react with the melt faster. Nearly 100% greater compactness means savings in weight and storage space. New "Compression-Spin" seal assures longer shelf life. Over 99.9% copper assay offers the near-ultimate in purity.

Three other handy sizes, 2.25 and 9.0 gram cartridges, plus a 108.0 gram charge in cup form, offer any combination of weights for introducing any percentage of lithium in the melt.

The 4.50 gram cartridge represents 0.010 lbs. of lithium rod. It will refine 200 lbs. of copper or copper-base alloy. All oxygen is removed, fluidity increased, pouring temperature often lowered, oxide and slag inclusions reduced, grain refined, and gas cavities eliminated—*with no change in conventional melting and casting processes.*

The end result is a superior casting: sounder, denser, more uniform, more electrically conductive—at less trouble and less cost. Write for details.

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SALES OFFICES: NEW YORK — CLEVELAND — CHICAGO — MINNEAPOLIS
Circle No. 193, Page 7-8

let's get personal

Donald McDaniel . . . has retired after 40 years of service as vice-president, Hamilton Foundry & Machine Co., Hamilton, Ohio, and president, Decatur Casting Co., Decatur, Ind. He will continue to serve as a director of both corporations.

As a pioneer foundryman in this country, McDaniel was one of the organizers of the Ohio State Foundrymen's Association in 1920, and served as a director during the life of the Association. He was active in development of the first Code of Uniform Trade Customs for the Gray Iron Castings Industry, adopted and published by the Ohio State Foundrymen's Association. Later he took part in revision of this code which became known as the Terms and Conditions of Sale for the Gray Iron Industry and approved by the National Association of Purchasing Agents.

McDaniel helped organize the Gray Iron Institute in 1928 which was reorganized as Gray Iron Founders' Society, Inc. This organization awarded him a citation honoring him for his "steadfast loyalty and service to the Society." He is also a member, AFS Cincinnati Chapter and the Engineering Society of Cincinnati.

R. S. Bradshaw, Jr. . . . was named president and general manager of Texas Foundries, Inc., Lufkin, Texas, replacing the late Colonel Cal C. Chambers. Bradshaw joined the company as plant manager when it was organized. He is a member, AFS Texas Chapter. The stockholders also elected two board members, **J. O. Klein** and **Cal C. Chambers, Jr.**

J. E. Abshire, Jr. . . . treasurer, AFS Tennessee Chapter is now associated with Porter Warner Industries, Inc., Chattanooga, Tenn. Porter Warner, president, stated, "Mr. Abshire handled research in sand and additives previously with Ross-Meehan Foundries, of this city, and will now act as sales representative and consultant for our firm."

R. S. McQuillan . . . has been promoted from salesman to vice-president of Empire Metal Products, Ltd., Vancouver, B. C., Canada. He is a member, AFS British Columbia Chapter.

Norman Dabney . . . Dabney Foundry Co., Ltd., New Westminister, B. C., Canada is now vice-president of the organization.

J. D. MacKenzie . . . American Smelting and Refining Co., New York, has been elected president. During his 38 years with the company he has come up through the ranks from a chemist and metallurgist to his present position. He is also director of General Cable Corp., New York, Revere Copper and Brass Inc., Rome, N. Y. The former president, **R. W. Vaughn,** is now vice-chairman of the

D. McDaniel

J. E. Abshire, Jr.

J. D. MacKenzie

board. He has been with Asarco since 1937. **R. L. Jourdan** has been elected vice-president. Jourdan has spent his entire business career with the company starting as a chemist and metallurgist.

A. W. Lang . . . recently was appointed chief metallurgist, Universal-

A. W. Lang

Rundle Corp., Camden, N. J., Lang is a member of the AFS Philadelphia Chapter.

F. J. Boeneker . . . has joined A.C.F. Industries, New York, as sales engineer. He formerly worked with the Bronze Alloys Co., and is a member, AFS St. Louis Chapter.

W. C. Watson . . . has been made chief engineer, Olney Foundry Div., Link-Belt Co., Philadelphia. He is a

W. C. Watson

graduate of Penn State University and member, AFS Philadelphia Chapter.

Walter Bonsack . . . became chief metallurgist of Aluminum and Magnesium, Inc., Sandusky, Ohio. Bonsack is a member, AFS Northeastern Ohio Chapter.

W. N. Brammer . . . will serve as sales manager for Pressure Castings, Co., Cleveland. He has an extensive knowledge of metal fabrication and metallurgy. He is the holder of molding machine patents and has authored a number of papers on alumi-

Metallurgists and Technicians...

HERE'S THE LAB

♦ LOW COST
♦ NEW PLOW DESIGN
♦ IDEAL FOR EXPERIMENTAL SAND MIXTURES
♦ EXACT CONTROL OF SAND PROPERTIES
♦ NEW LARGE INSPECTION DOOR
♦ NEW TILTING MECHANISM
♦ NEW OPERATING EASE

New plow design, scientifically contoured mulling bowl, and rubber-tired mulling wheels assure thoroughly mulled sand batches which very closely duplicate molding and core sand mixtures prepared by production Speedmullors. The new Lab Mulbaro provides close laboratory control of sand preparation and permits practical, low cost experimentation with the many new binders. Mulltrol is available for batch after batch uniformity through precise control of the mulling cycle. Lab Mulbaros quickly pay for themselves through improved sand control, improved sand properties and the ensuing improvement in casting quality.

Tilting mulling mechanism and removable mulling bowl make the new Lab Mulbaro the ideal foundry tool . . . easy to use, easy to clean.

Write today for complete information
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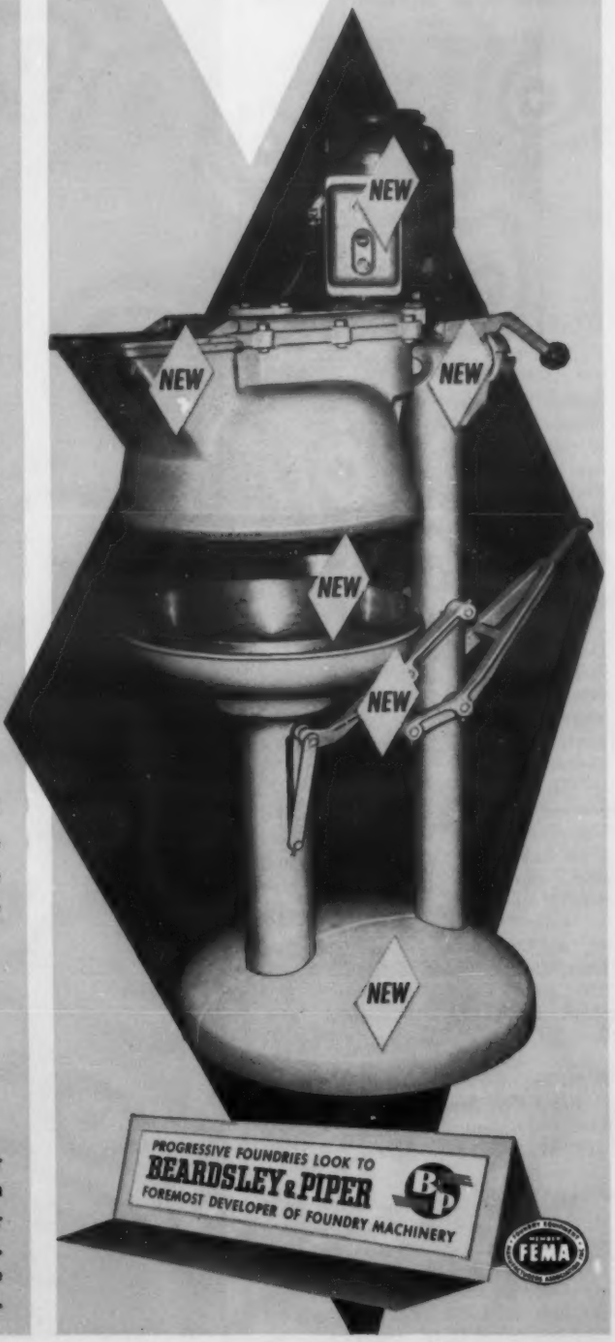
NEW MULBARO



Circle No. 194, Page 7-8

num which were presented before S.A.E., A.S.T.M. and AFS groups. He is currently an active member of the AFS Alloys and Properties Committee of the Die Cast and Permanent Mold Division. Brammer is a member of the AFS Northeastern Ohio Chapter.

W. W. Goessel . . . recently transferred by Beloit Eastern Corp., to take over duties as foundry superintendent in the Downington, Pa., plant. He was formerly a member of the AFS Milwaukee Chapter and has been elected as a director, AFS Philadelphia Chapter.

W. W. Goessel

D. R. Chester . . . was elected chairman, AFS Sand Division Committee (8-C), at the March meeting held in the Carter Hotel, Cleveland. Chester, Federal Foundry Div., Archer-Daniels-Midland Co., Cleveland, is a member of the AFS Northeastern Ohio Chapter. **D. S. Mills,** General Motors Corp., Detroit, was elected vice-chairman. He is a member, AFS Detroit Chapter.

Jerome Strauss . . . vice-president, Vanadium Corp. of America, New York has retired. **A. F. Sparkle** has been appointed assistant vice-president.

M. A. East . . . general manager, John East Iron Works, Ltd., Saskatoon, Sask., Canada, is now president of that firm. He is a member, AFS British Columbia Chapter.

R. N. Thompkins . . . Western Foundry Sand Co., Seattle, Wash. has become president. He is a member, AFS Washington Chapter.

F. M. Moses . . . Wilson & Geo. Meyer & Co., San Francisco, has been promoted to position of manager, coke department. **L. N. West,** executive vice-president said, "West joined the firm in 1954 after service with Carnegie Steel Corp. and Pan Amer-

YALE introduces...the INDUSTRIAL tractor shovel

DESIGNED TO GIVE YOU 25%

See it in action... let your operator drive it!

He'll like the roomy, uncluttered, comfortable cockpit. Adjustable seat gives him plenty of leg and foot room. Finger-tip controls conveniently located. Yale Torque Transmission with one speed forward and reverse —one directional control lever. He'll especially like Yale's exclusive Safety-Curve Arms. Gives him plenty of safe, elbow room—and extra visibility when bucket is raised. For a demonstration in your plant or for further information, write The Yale & Towne Manufacturing Co., Philadelphia 15, Pa., Dept. A-1055.

Circle No. 195, Page 7-8

MORE WORK EVERY HOUR

through these exclusive Yale features...

- Yale Torque Transmission (fully automatic)
- 45° ground-level bucket tipback
- Safety-curve arms
- Accelerates to operating speed of 8 mph. in 3.5 seconds—to a speed of 13 mph. in 5.5 seconds
- 6 foot dumping clearance
- Sealed brakes
- Front and rear operating lights

At last—a tractor shovel designed especially for industry! Whether you handle bulk chemicals, sand, gravel, scrap or raw materials, you'll get more productive work at less cost per work unit with this new concept in a tractor shovel.

Yale designed it for tight areas—built it *compact* (only 117" overall length) so that it can maneuver in any aisle wide enough for a wheelbarrow. *Accelerates to an operating speed* of 8 mph. in 3.5 seconds and to a top speed of 13 mph. in 5.5 seconds. Exclusive *Yale Torque Transmission (fully automatic)* permits quicker, smoother starting, eliminates shifting, provides more power under load conditions—in a word, *speeds cycle operations*. This extra speed, plus the greatest carrying capacity of its class (full 2500 lbs.) means *up to 25% more work per hour*.

Yale's loader-linkage design offers unique advantages. Exclusive 45° *Ground-Level Tipback* insures the ultimate in loading action—and a grade-level carrying position to minimize spillage. Exclusive 6 foot *Dumping Clearance* is highest on any model of similar wheelbase. Bucket is *Automatically Self-Locating*. Operator merely lowers from full dump-position to ground-level—bucket automatically returns to digging position.

a product of Yale's integrated design—these engineering advances are standard features

- Gasoline; LP-Gas powered
- Sealed hydraulic system—keeps dirt out
- Pre-cleaner—air cleaner combination
- Extra strong heavy welded steel frame—greater safety, longer life
- Automatic bucket return to digging position
- Carrying capacity of 2500 lbs.—bigger load capacity
- Short wheel base—minimum turning radius
- Sealed generator and distributor
- Balanced weight distribution
- Maximum speeds up to 13 mph.

YALE* *REG. U. S. PAT. OFF.

YALE & TOWNE

INDUSTRIAL LIFT TRUCKS & TRACTOR SHOVELS • HOISTS

GASOLINE, ELECTRIC, DIESEL & LP-GAS INDUSTRIAL LIFT TRUCKS • WORKSAVERS
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YALE MATERIALS HANDLING DIVISION, THE YALE & TOWNE MANUFACTURING CO. MANUFACTURING PLANTS: PHILADELPHIA, PA.; SAN LEANDRO, CALIF.; FORREST CITY, ARK.

Circle No. 195, Page 7-8

ican World Airways and will make his headquarters in San Francisco working with the trade out of Meyer company's four other Western offices." Both men are members of AFS Northern California Chapter.

L. J. Miller . . . has been named executive vice-president of A. P. Green Fire Brick Co., Mexico, Mo. Miller joined the company in 1923 as

L. J. Miller

shipping and production clerk, was later appointed general superintendent and in 1942 became vice-president.

R. C. Johnson . . . has joined the staff of the Manufacturing Chemists' Association, and will be identified primarily with M.C.A. activities in the field of special metals. Johnson is the author of numerous technical papers and the holder of 15 patents.

P. W. Beamer . . . has been appointed manager, sales and development, Utica Metals Div., Kelsey-Hayes Co., Utica, N. Y. He is active in metallurgical societies and his publications include several articles on specialized phases of metallurgy. **Dr. E. S. Machlin,** on sabbatical leave as associate professor of metallurgy, Columbia University, has been appointed acting director of research. Machlin has co-authored over 40 technical papers devoted to physical metallurgy and is the recipient of the 1954 Matthewson Gold Medal of the Institute of Mining and Metallurgical Engineers.

J. F. Torley . . . has accepted the position of manager, National Malleable & Steel Castings Co., Cicero, Ill. Torley is a member, AFS Chicago Chapter.

Paul Yavorsky . . . is the new Technical Director, Zirconium Corp. of America, Solon, Ohio. Mr. Yavorsky has been associated with the high

Continued on page 27

NEW

HAWLEY
Trav-L-Vent
"Moves with the job"

eliminates big, expensive area ventilating systems

exhausts toxic fumes at any pouring point

• *First and only* real solution to non-ferrous foundry ventilating problems. Eliminates "zinc shakes" and other health hazards . . . improves working conditions. Pays for itself in heat saved. *Installs at less* than ⅓ the cost of inefficient, conventional systems . . . uses as little as 1500 cfm. Will fit *your* foundry layout. Write now for complete information . . . to Martin Equipment Company, Box 173, Wabash, Indiana.

HAWLEY MANUFACTURING COMPANY
Wabash, Indiana
Circle No. 196, Page 7-8

the editor's field report

by Jack Salmon

■ Seventeen consecutive months of full foundry employment and a record breaking 1957 are the direct result of creative selling by Northern Malleable Iron Co., St. Paul, Minn. In a talk at the Malleable Founders Society Ninth Market Development Conference, George T. Boli, company president, said, "creative selling has been a strong factor in obtaining 313 new malleable casting jobs during 1957." Many of these were conversions from weldments, forgings and from other cast metals. Company salesmen are trained in every department of the foundry before contacting any customers. Creative selling requires the salesman to have a mechanical understanding, basic knowledge of product, design ability, insatiable curiosity, patience and persistence.

■ Want to evaluate your core-box design by proving the absence (or presence) of undesirable erosive action during blowing? This may not be an official AFS or A.S.T.M. standard test procedure but it's quick, simple and impressive. Just lay a single sheet of tissue paper on bottom face of core box. Blow core. Remove from box. Now where's the tissue? If tissue is neatly pressed into the outside contour of the core then blowing action is good. If paper has been disintegrated by the impact and scouring action of the sand, then you have a core-box problem. The box will soon be headed back to the shop for expensive repairs of surface damage. Erosive wear can be eliminated by proper redesign of box or blowplate.

■ King size briquettes of iron and steel borings and turnings will soon be available as a raw material for charging cupolas. A scrap metal dealer in Beloit, Wis., says that he can collect turnings and sell the 40-lb briquettes competitively within a 150-mile radius of his yard.

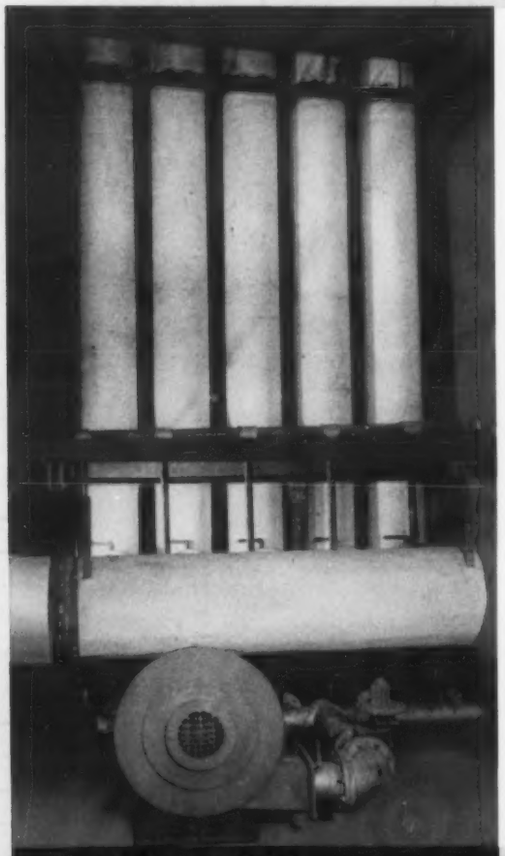
■ Ever see centrifugal molding? It's being done at the new Combustion Engineering foundry in Chattanooga, Tenn. Soil pipe is produced in this highly mechanized and automated plant by the centrifugal casting process. Molding also utilizes centrifugal force. Pipe flask raises to a vertical position and is filled with green sand as it slowly turns. Flask tips to horizontal and rotation speeds up to 1000 rpm. Centrifugal force packs the sand lining in flask. Final compacting and smoothing of sand lining is accomplished by inserting a spinning mandrel into the mold cavity. Whole operation takes less than a minute!

■ The missile industry needs structural materials possessing high strength and light weight combined with high damping capacity. A new magnesium casting alloy has recently been created to meet this need. The light alloy develops a greatly improved yield strength while retaining an excellent degree of damping capacity. The mag alloy is already finding success in its first prototype missile applications.

Circle No. 197, Page 7-8

NOW HOT BLAST AIR FOR YOUR CUPOLA

500° TO 1200°



W. O. LARSON
Foundry Company
Grafton, Ohio

Cuts Cupola Coke Consumption Up to 30%

"Hot Blast" air preheaters offer dramatic new advantages to the foundry field.

1. **Up to 30% coke savings**
2. **Better control of hot metal temperature**
3. **Silicon oxidation losses reduced**
4. **Improved sulphur control**
5. **More rapid heating**
6. **Increased metal production**
7. **Hotter iron at the mold**
8. **Production of better castings**
9. **Metal charge can be of lower quality**

Get the Facts -

VISIT OUR BOOTH...

 # 1662

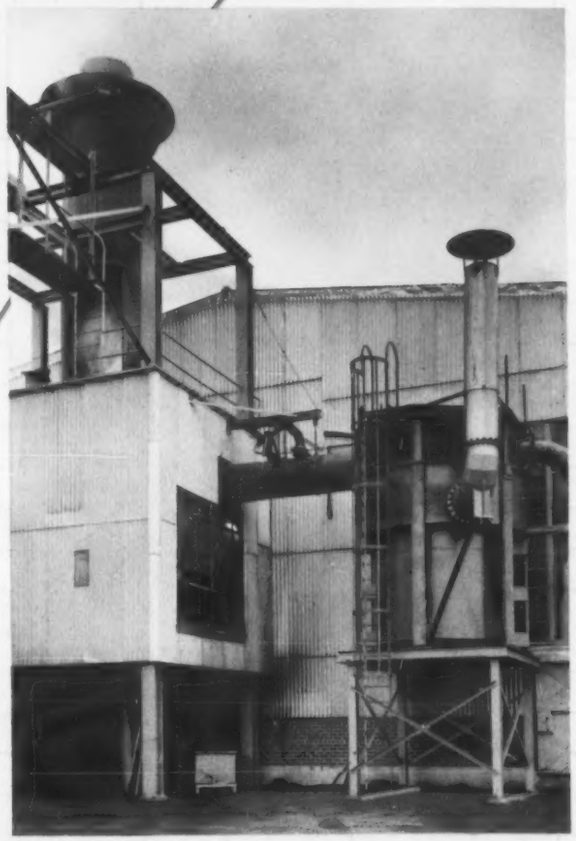
AT AFS CONGRESS

THE BROWN THERMAL DEVELOPMENT CO.

Subsidiary of Brown Fintube Company
Elyria, Ohio

Litho in U.S.A.

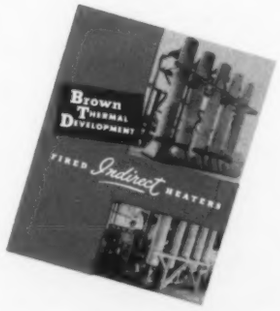
BROWN
Thermal Preheaters
HOT
BLAST AIR
At 1200° F. for



James B. Clow & Sons Coshocton, Ohio

In November, 1957, the Brown Thermal Development Company installed a 6,000 cubic foot Hot Blast Preheater at the James B. Clow & Sons Plant, Coshocton, Ohio. This unit is now furnishing hot blast air up to 1200° F. Units like this offer foundries the following advantages:

- A return of up to 30% in coke savings a year is possible.
- Use of Brown's Fintubing application, to increase surface area, which reduces physical size of preheaters and assures higher efficiency.
- Unique counter-flow principle to obtain ultimate in thermal efficiency.
- A completely packaged unit including burners, controls and safety devices.
- Fully automatic for ease of operation.
- Completely instrumentated for accurate temperature control.
- Large capacity (6,000 to 15,000 cfm up to 1200° F.)
- Backed by 20 years of heat transfer engineering.



YOURS FOR THE ASKING
Learn how Brown Thermal Hot Blast Heaters can slash coke costs and produce better castings. Write for complimentary copy of Bulletin No. 586.

BROWN THERMAL PREHEATERS

THE BROWN THERMAL DEVELOPMENT CO.
Subsidiary of Brown Fintube Company Elyria, Ohio

let's get personal

Continued from page 23

temperature ceramic industry since 1939 and has co-authored several articles on this subject, as well as zirconia, beryllia and thoria.

A. J. Rumely, Sr. . . . has been elected chairman of the board of directors, La Porte Foundry Co., La Porte, Ind. Other elected officers are **A. J. Rumely, Jr.,** president and treasurer; **P. J. Menkhaus,** vice-president and general manager; **E. A. Miller,** secretary and comptroller; and **F. O. Borg,** foundry superintendent. Both Miller and Borg are members, AFS Michiana Chapter.

Henry Ford II . . . president, Ford Motor Co., Dearborn, Mich., announced the realignment of manufacturing activities and changes in executive responsibilities. **D. S. Harder,** retirement age, resigned his office as executive vice-president and will serve on the staff as vice-president and technical advisor to chairman of the board. **John Dykstra** has been appointed to fill this vacancy. **R. H. Sullivan,** who will retire in September, will continue as company vice-president and will collaborate with Harder on special manufacturing projects for the company.

C. H. Patterson has been elected vice-president and will head the Power Train Group. This includes Engine Foundries Div., with **M. L. Kate** general manager; and Transmission and Chassis Div., headed by **R. J. Hampson** general manager. **I. A. Duffy,** vice-president, will direct the Body Group with the Tractor and Implement Group headed by **M. D. Hill.**

Ford's realignment program rearranges plants into six manufacturing divisions which become components of the two new groups—Power Train and Body.

W. R. Lewis . . . became works manager of Electro Metallurgical Co., Div. Union Carbide Corp., New York. He started as a student engineer with the company in 1941.

R. O. Offill . . . has been promoted to advisory engineer, Lindberg Industrial Corp., Chicago. He will assist field personnel throughout various district offices.

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Circle No. 198, Page 7-8

One of a series on:

why practical foundrymen select Simpson *MIX-MULLER* by four to one

American Abrasives Metal Co., Irvington, N. J., saved $2500 in bond alone during first year operating their 2F Mix-Muller.

Studebaker-Packard Corp. Manifold line —Sand output tripled; sand quality improved . . . moisture control improved . . . since installation of 2½F Mix-Muller. Is one of 13 Mix-Mullers used at South Bend, Ind. Foundry.

"Use of bond in system has been cut by 50% with no loss in quality." Superior Foundry Company Cleveland, Ohio

". . . our mulling cycle has been cut by 30% due to increased capacity and reduced mulling time. Facing has been eliminated." Xenia Foundry & Machine Co. Xenia, Ohio

How Simpson mulling principle can save you up to 50% in bond cost

When a batch of sand and bond is mulled the sand will achieve *most* of its green strength early in the process . . . But, *most* isn't always good enough to do all jobs. Scrap, inferior castings, wasted time, money and material are poor reward for a half mulled batch of foundry sand—when the total savings in mulling time may be less than a minute.

There is another way to save mulling time . . . *use a great deal more bond.* You'll get your strength but it will still be earned at the expense of questionable sand quality . . . and bond is costly.

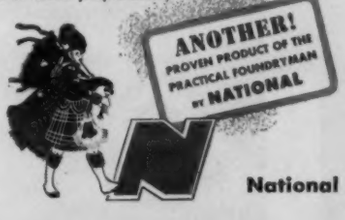
Some foundrymen make a choice—time or bond, but many more *get both* by doing one of two things:

(1) Changing to Simpson Mix-Muller
(2) Using their present Mix-Muller wisely

These *practical* foundrymen know from experience, that they may mull a batch a little longer in a Simpson but they also know that, model for model, the Mix-Muller can turn out more, better sand in a given time than any other sand mixer!

Yes, you can save on bond with the Mix-Muller

. . . up to 50% as reported by users—but you'll save in six other ways too. Combined, these savings mean much more to practical foundrymen than a few seconds saved in mulling. They are the reason why, for almost 50 years, Simpson Mix-Muller has been the choice of *practical* foundrymen by four to one over any other means of sand preparation.



SIX WAYS YOU SAVE WITH MIX-MULLER

GET MORE FOR YOUR EQUIPMENT DOLLAR WITH MIX-MULLER

Model for model, you'll mix more sand—get more tonnage per hour with large capacity Mix-Muller.

SAVE RAW MATERIALS WITH MIX-MULLER

Only *true* mulling permits you to use lean mixtures. You'll make the most of *less* oil, binder and other additives—and get top quality sand at the same time.

YOU SAVE SCRAP WITH MIX-MULLER

True mulled sand cuts down on casting, mold and core scrap.

YOU SAVE CLEANING COSTS WITH MIX-MULLER

Uniformly coated sand means better finish—right from the mold with less cleaning.

YOU SAVE POWER WITH MIX-MULLER

Mix-Muller takes only about ½ the power of other machines—to do the same or a better job. Only power required is used to plow and to roll mullers over the sand.

YOU SAVE MAINTENANCE WITH MIX-MULLER

Simple, rugged construction makes Mix-Muller easy to operate, maintain—and get parts for. Low speed mulling insures longer wear and part life to save you materials and man hours.

F-758

National Engineering Company, 630 Machinery Hall Bldg., Chicago 6, Ill.

REPORT on the 62d AFS CASTINGS

Big annual event combined program of modern casting technology with new-look in foundry equipment & supplies

Confidence in the future was displayed by over 12,500 men of the metalcasting industry attending the AFS 62d Castings Congress & Show in Cleveland, May 19-23. Foundrymen came to see the very latest in equipment and supplies and to learn about the most recent advances in modern foundry technology. Displayed in 94,000 square feet of floor area in the Cleveland Public Auditorium, some 221 exhibitors presented to the metalcasting industry the most modern display of foundry equipment, supplies and techniques ever seen. Over 100 technical papers were contributed by top-ranking men of the industry in a program that covered the complete gamut of modern foundry practices.

■ **REGISTRATION**—With an advance registration of over 5000, attendance exceeded all expectations. Close to 100 foreign visitors from 17 different countries served to emphasize the international importance of the week's events. At least nine of the exhibitors featured equipment or materials produced overseas. Old Timers registration for men employed 25 or more years in the foundry industry revealed over 100 patriarchs of metalcasting present during the week. Top honors went to Barney Bernbaum who started his foundry career in 1884 at the age of 13. Now 87 years old, he is in his 74th year of active service.

■ **MODERN CASTINGS DAILY**—This year the Modern Castings Daily newspaper was introduced as a new service to exhibitors and visitors. Free copies were available to everyone attending the show each morning. The Daily listed the names of all men registering for the Congress and Show. Also covered were the highlights of each day's activities, technical program, social affairs, photos of exhibits, events and convention personalities, abstracts of technical papers and AFS activities.

■ **HOYT MEMORIAL LECTURE**—High point of the technical program was set with the annual Hoyt Memorial Lecture—"Silicon: Present and Future"—presented by Walter E. Remmers, vice-president, Union Carbide Corp. Speaker Remmers told the importance of silicon in modern metal alloys and chemicals used in foundries. As one of the most abundant materials on earth, new uses for silicon promise profound influence on man's future.

■ **BANQUET SPEAKER**—Featured speaker at the annual banquet was Dr. Ralph Lapp, fluent authority on the uses of atomic energy. Speaking on "Men, Rockets and Atoms", Dr. Lapp explained the amazing phenomena of nuclear warfare in outer space and the problems associated with developing an effective anti-missile for intercepting an enemy ICBM.

■ **GOLD MEDALS**—Gold Medal Awards, highest honor bestowed by AFS, were presented to three recipients by Edwin Horlebein, Chairman of the Board of Awards. Ralph A. Clark, Electro Metallurgical Co., Div. of Union Carbide Corp., received the Thomas W. Pangborn Gold Medal for "outstanding contributions to the Society and ferrous casting industry, especially in the field of gray iron metallurgy." William W. Maloney,

Large crowd of foundrymen lined up for registration when 62d Casting Congress and Foundry Show opened at the Cleveland Public Auditorium.

Prior to Show Opening, AFS officers inspect exhibits for safety.

AFS President Harry W. Dietert addresses the Wednesday Business Meeting.

CONGRESS and SHOW

AFS Secretary and General Manager, received the Joseph S. Seaman Gold Medal for "enthusiastic leadership and completely unselfish devotion to the Society as its Secretary and General Manager." Howard J. Rowe, Aluminum Co. of America, received the William H. McFadden Gold Medal for "outstanding contributions to the Society and to the light metals branch of the castings industry."

■ **BUSINESS MEETING**—Awards were also made at the annual business meeting after AFS President Harry W. Dietert presented his final report to the members on "Current AFS Developments". AFS Service Citations were presented to Frank S. Brewster, Ernest T. Kindt, and Frederick G. Sefing. Recipients of the AFS Award of Scientific Merit were Mervin H. Horton, Kenneth H. Priestly and Franklin B. Rote. The first and second place winners of the AFS Apprentice contest received trips to the show, certificates and checks from President Dietert at the Business Meeting. New officers and directors elected are featured on page 35.

■ **CANADIAN DINNER**—The gay Canadian dinner was honored with the presence of Sir Frank Markham, member of Parliament, past Private Secretary to three Prime Ministers and Director of Foundry Equipment Ltd. The entire foundry industry was shocked to learn Thursday morning of the death of Alex Pirrie, national AFS director from Canada, who had so ably toastmastered the Canadian dinner.

Sand Division Dinner featured talk by Clyde A. Sanders on European methods and film on automated molding and pouring. Hoyt Lecturer Walter Remmers (right) outlined the future of silicon.

■ **COMMITTEES**—A great deal of the success of the 62d Castings Congress & Show should be credited to the members of the various committees sponsored by the AFS Northeastern Ohio Chapter.

AFS President Harry W. Dietert presided at Annual Banquet and received Honorary Life Membership. Three Gold Medals were awarded. Dr. Ralph Lapp (right) discussed ramifications of atomic warfare.

Ladies Program opened with Tea. Left to right, Mrs. Jeter, Mrs. Barczak, Mrs. Dietert (pouring), Mrs. Durdin and Mrs. Sibbison.

REPORT on the SHOW

In move toward mechanization and modernization castings industry creates buying spree at Cleveland

"Sold to ———— Foundry" was the emblem of success that hung from practically every piece of equipment on display at the big AFS Show in Cleveland. Exhibitors, skeptical of finding customers in a slow period of foundry business, were overwhelmed with an unprecedented number of buyers.

One company sold its entire exhibit, $100,000 worth of equipment the first day of the show and tripled its sales before the week's end. A shell core-blowing manufacturer wrote-up a half million dollars worth of business during the week. Exhibitors were almost unanimous in praising the quality of the foundrymen touring the show. Casting producers had sent only their best men with one key thought in mind —modernize and mechanize for the future.

Most of the exhibitors unveiled new products or new designs to meet the needs of small and large foundries for producing castings faster—cheaper—and better.

ARENA

Inco has new ductile Ni-Resist.

Cornell showed new desulfurizer.

Baroid featured Bentone binders.

Hickman, Williams is 68 years old.

Dexocor binder for all cores.

Apex distributed technical data.

Ferrocarbo aids machineability.

U. S. Gypsum epoxy patterns.

Oliver universal pattern mill.

Zircon facings produce savings.

Light-weight "easy-off" flasks.

AUDITORIUM

Pittsburgh and subsidiaries are malleable shot and grit producers.

Superkoat, for shell cores, penetrates and coats hot or cold cores.

Magnaflux can find hard spots.

The coke with the lowest sulfur.

Hi-Flex cast aluminum flasks use special pivot pin for custom fit.

NORTH HALL

Eastern Clay Products demonstrated redesigned Taconne molding machine.

A-D-M's improved core blower.

Lectromelt arc furnace model.

Showing a new carbon additive.

Sterling National introduced an aluminum "squeeze-in" bottom board.

ARCADE

Multiductor induction furnace.

Dependable's shell core blower.

Union Carbide demonstrated the merits of new refined charge chrome.

Lindberg's new holding furnace.

Brown Fintube hot blast units.

Osborn's display introduced a new shell core blowing machine.

Link-Belt sand handling system using oscillating and belt conveyors.

Pneumatic sand handling system.

B&P stack blowing and CO_2 unit.

UPPER LAKESIDE HALL

Hough featured new H-25 model.

TV in the Modern Equipment booth.

Pekay displayed equipment for rapid cooling and aeriating of sand.

Whiting water-cooled cupola.

FOSECO showed complete line.

Pangborn exhibited four sizes of Rotoblast barrel cleaning machines.

LOWER LAKESIDE HALL

Prospective buyers interview salesmen in the Spo and Coleman booths.

Jeffrey electric vibrators.

Plant design by Lester B. Knight.

National Engineering unveiled low pressure air conveyor for sand.

FE North American introduced line of British-built molding machines.

REPORT of AFS ELECTIONS

■ The AFS national nominating committee presented recommendations for new officers and directors at the business meeting May 21; the nominations were unanimously approved.

Lewis H. Durdin, Dixie Bronze Co., Birmingham, Ala., is the new national president; Charles E. Nelson, Dow Chemical Co., Midland, Mich., was elected vice-president. Harry W. Dietert, Harry W. Dietert Co., Detroit, immediate past president, will remain on the board of directors for one year.

The AFS board of directors consists of the president, vice-president, immediate past president and 21 others. Six board members are elected at the annual meeting to serve terms of three years each. One member is appointed annually by the board. Clyde A. Sanders, American Colloid Co., Skokie, Ill., was appointed to the board of directors at the director's meeting in February.

The six newly elected directors are:

David W. Boyd, Engineering Castings, Inc., Marshall, Mich.

T. W. Curry, Lynchburg Foundry Co., Lynchburg, Va.

R. R. Deas, Jr., Hamilton Foundry & Machine Co., Hamilton, Ohio.

Jake Dee, Dee Brass Foundry, Houston, Texas.

Webb L. Kammerer, Midvale Mining & Mfg. Co., St. Louis.

H. M. Patton, American Hoist & Derrick Co., St. Paul, Minn.

L. H. Durdin
Newly elected AFS president

C. E. Nelson
Elected to vice-president

H. W. Dietert
Remains on board for one year

D. W. Boyd

T. W. Curry

R. R. Deas, Jr.

C. A. Sanders

Jake Dee

W. L. Kammerer

H. M. Patton

REPORT on CASTINGS TECHNOLOGY

Meet the foundrymen responsible for creating the new technology that helps keep the industry competitive

Many of tomorrow's routine foundry practices were previewed as advanced metalcasting technology in the 94 papers presented during the 62d Castings Congress. A total of 140 authors contributed their experiences to the 37 technical sessions sponsored by the following AFS Technical Divisions—Sand, Pattern, Steel, Gray Iron, Malleable Iron, Ductile Iron, Light Metals, Die Casting & Permanent Mold and Brass & Bronze. Sessions were also organized by the following Committees: Fundamental Papers, Heat Transfer, Plant and Plant Equipment, Industrial Engineering and Cost, Management, Noise Control and Radiation Protection.

Some of the significant advances revealed during the Castings Congress were—Salt bath heat treatment of malleable iron yields better physical properties than conventional quench and temper treatments. . . . Plastic patterns can be designed rugged for use on jolt-squeeze or diaphragm molding machines at one-half the cost of metal patterns . . . Surface defects on low-carbon and low-alloy steel

AFS Gold Medal Award winners, left to right, W. W. Maloney, H. J. Rowe and R. A. Clark, receive congratulations from E. W. Horlebein.

Board of Awards Chairman, E. W. Horlebein, left, presenting AFS Awards of Scientific Merit to M. H. Horton, K. H. Priestley and F. B. Rote.

Speakers and officers of Sand Session—Steel Casting Molds.

Newest AFS technical division, Ductile Iron, is chaired by C. W. Gilchrist, seated, far left.

Opening Light Metals Session discusses reactive metals; R. E. Edelman, seated, right, presiding.

FOR TOMORROW

castings in shell molds can be eliminated by using molds made with forsterite or blends of granulated limestone and silica sand . . . Water cooling electric furnace shell lengthened arc furnace refractory life to 331 heats . . . Scrap titanium can be remelted by induction furnace and cast with properties approaching that of forgings . . . The complete explanation of these and many more discoveries are available in official technical papers which appear each month in the Transactions Preview department of MODERN CASTINGS.

As usual Shop Courses proved so popular that five were scheduled—two Gray Iron, two Malleable and a Sand Shop Course. Seven Round Table Luncheons broadened the scope of the technical program.

The important conclusions reached in some of the technical papers presented at the Congress appear on pages 120-127 and 138.

Authors and chairmen met daily at breakfast to outline activities and make final arrangements for division meetings.

Service Citations for outstanding contributions were awarded by E. W. Horlebin, right, to E. T. Kindt, Fred Sefing, Frank Brewster.

Malleable shop course speaker L. R. Jenkins flanked by presiding officer, Truckenmiller and chairman, Welander.

Management Luncheon, C. E. Westover presiding, featured two speakers, R. B. Parker, center, R. Monsalvatge, right.

Malleable shop course officers and authors.

T. E. Norman address Steel Division session.

Pattern Division group plans Monday meeting.

IDEA TOUR

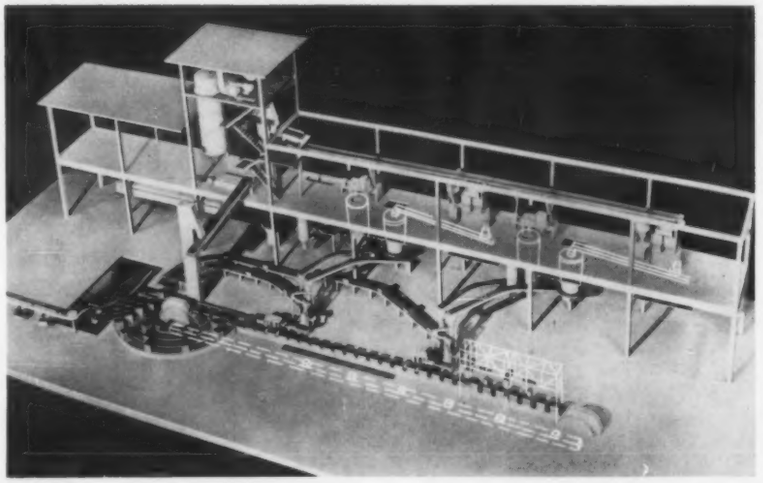
OF EUROPEAN FOUNDRIES

How is Europe making important advances in the science of metalcasting?

C. A. SANDERS / *Vice-President*
American Colloid Co.
Skokie, Ill.

This article is a report on some of the developments witnessed in at least 80 foundries abroad during a recent three-month intensive study of foundry operations in eight European countries. If one observation could be made from these experiences, it would be this: that foundry developments in Europe have resulted from fundamental studies of science and engineering, whereas in contrast American foundrymen have concentrated more on plant expansion and mechanization. Perhaps this is why so many American foundrymen on going abroad have looked in vain for the European counterpart of the "concrete and steel jungle" of plant and equipment so familiar in this country. In Europe the real developments in foundry practice are going on behind closed laboratory doors, not on the molding floor.

Many of the developments seen abroad are not even widely known throughout Europe because the American way of free interchange of information through such organizations as the American Foundrymen's Society is not the European way. Startling developments are taking place on the continent and in England, many of them "closed secrets" and revealed only on promise that they would neither be photographed nor discussed. Nevertheless, technological progress in Europe on engineering and scientific fundamentals of metal casting must cause an American observer to pause and reflect.



Scale model of George Fischer Ltd. automated foundry in Switzerland.

If our foundries, like our educational institutions, turn their thoughts to the same basic principles that are being studied in foundry circles abroad, developments in metalcasting in the next 15 years could again revolutionize the entire American foundry industry.

Research and Development

There appears to be more national research development data and free technical literature available to foundrymen on this side of the Atlantic than in Europe but more *individual foundry research* going on in Europe. The results of many research problems in Europe may be available only to that company, or companies, sponsoring the research.

Most European companies employ a technical staff of the highest calibre and have foundry laboratories far ahead of North American facilities. The European laboratory constantly makes a greater effort to become perfect, whereas we are more apt to hasten projects toward production.

Pattern Design

Design engineers work closer with the pattern shop in Europe than in North America. The majority of European foundries attempt to settle most production problems in the pattern shop. In general more of the administration staff is concerned with planning in the pattern shop than corrections in the foundry. It appears that the pattern foreman or supervisor influences management more than the foundry supervisor.

Patterns are modified as required to aid production problems. In certain cases is was observed that the foundry did not have as close a liaison with the customer as the pattern shop. All ills seem to be cured in the pattern shop. In this country the pattern shop is not as close to management. Also it is more common to depend on outside pattern shops to produce patterns for the foundry.

American foundrymen are often guilty of bragging about the high productivity achieved in U.S. foundries. However, Europeans can match our superlatives when it comes to a comparison with the George Fischer Ltd. automated foundry in Schaffhausen, Switzerland. American foundries would have difficulty meeting the production rate of this malleable foundry. Automatic molding machines produce approximately 300 molds per hour, a total of approximately 2400 molds per eight hours! The flask size used is 22x27 in. and 6-12 in. in height. Pattern plate is approximately 600 sq in. in area.

Automation

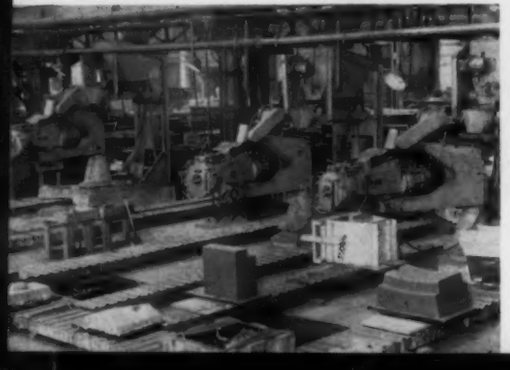
When one observes the completely automatic system for adding both facing and backing sand to flasks, he is quick to recognize the European's ability and ingenuity.

Copes and drags are automatically jolted and squeezed and passed to the conveyor stations without the aid of a molder. There the cores are set manually. The number of hands at this station depend on the number of cores to be placed in the drag. The flasks are closed and weights automatically placed on them before they pass to the automated pouring conveyor station. It was fascinating to watch ladles traveling parallel to the conveyor line, find their place under the reservoir holding ladle, and gear themselves automatically into the conveyor system ready for pouring. Metal is weighed as it is tapped into ladles. Rapid pouring at a constant height above the mold is made possible by a planetary system of ladle mounting.

After molds are poured they pass to the cooling area where shakeout time is varied by an ingenious roller conveyor system.

Cores are rammed with slinger by F. H. Lloyd & Co., Staffordshire, Eng.

F. N. Lloyd, F. H. Lloyd & Co.



Only 9 men are needed to operate this fantastic mechanized foundry. It is amazing to see how this company has integrated all the plant operations—sand cooling, preparation and handling; molding; pouring and shakeout.

Mechanization

New equipment is gradually being introduced into the European foundry but many companies have not been fully convinced that equipment will solve their problem. They are still considering the most effective method to produce castings in their foundry and do not want to make a hasty, incorrect decision.

I believe the European has yet to recognize the full possibilities of two prominent pieces of equipment used extensively in the States, namely the sand slinger and core blower. Because there is an abundance of craftsmanship, some companies have not taken advantage of these work-saving devices. An exception to this is the use of small sandslingers by F. H. Lloyd & Co., Staffordshire, England, to ram cores with oil or clay-bonded sand. Each slinger serves two roller conveyors. Core box, complete with iron, is delivered to slinger from rear. Rammed box moves forward for stripping. This practice saved as much as 75 per cent time over conventional ramming. Where mechanization has been adopted it appears to be equal to any of ours and receives more preventive maintenance care.

It was strongly noticed that in general, European foundries lack the art of servicing production molders. Their molders are not provided with a steady supply of sand, cores, flasks, bottom boards and other materials. European visitors to this country are invariably impressed with the smooth flow of materials to and from molding stations.

Sand Handling

There has been a decided increase lately in sand-handling equipment purchased. Foundries installing a sand slinger have found it necessary to use a system containing elevators, conveyors, storage hoppers and mullers to properly service the slinger. Several small stationary sand slingers with draw-type arms were in use for ramming small molds.

More European smaller foundries realize that if they pay molder's wages they must eliminate the molder from doing common labor chores. By adding an elevator with two hoppers which feed sand to the molders, labor is reduced, molding becomes less tiring and time spent performing molding operations increases.

A few European foundries visited had elaborate sand-handling equipment. One in particular had more dust control in evidence around the sand conditioning plant than ever seen in United States foundries. The equipment was spotless and not a single operator was seen on the sand-handling platform. The operator was actually located in an air-conditioned room, operating a large control panel board. A well-lighted, control-board panel showed the location of sand and all raw materials as they passed through the system. The operator could mull and transport a batch of molding sand to any location in the foundry quickly and efficiently.

It reminded the writer of a large railroad dispatcher's control panel. Even a person unfamiliar with the foundry could manipulate the switchboard correctly and observe the raw materials being assembled, mulled and delivered to the molding stations. This lighted panel board could be read as throughly as an engineer reading a blueprint.

As in North America, there is not enough sand storage in European foundries. Perhaps money is spent for molding machines and production equipment before the need of ample sand storage is considered. Lack of hopper capacity is the chief reason for undesirably hot sands within North American foundries. This shortcoming is being recognized and rectified in recent European installations.

Many monorail sand systems were employed in Europe for delivering molding sand to molding stations. Servicing the molding production stations is still a European problem which will eventually be solved. Pneumatic sand handling is not yet popular but will probably be used more in the future because of the small size of most overseas foundries.

For the most part sand reclamation equipment is used only in a few large mechanized shops. It is believed that productivity equipment will be purchased before reclamation equipment.

Molding and Molding Sands

European foundries use more naturally bonded sand than the average North American foundry. Even many of the steel foundries are still utilizing naturally bonded sands. However, their steel casting success is due to the considerable attention given the mold. A great amount of nailing and coating is usually required.

Considerable loam molding for large cylinders and pipe is used. A brick framework is added to the rear of the loam and sweeps are used to form the mold contour. Where loam is used, and even in some foundries where dry sand is used with naturally bonded sands, an amount of chopped straw is added to help eliminate sand expansion defects and to overcome certain surface defects. These foundries also use a vast amount of chill nails.

Their molding sand, in general, is weak; so many bars, rods and gaggers are employed.

The European tends to use more dry sand. He reasons that it is safer and a better guarantee of a good casting. He realizes molding is expensive and should not be re-

Control panel for sand handling at English Steel Corp., Sheffield, Eng.
Dr. C. J. Dadswell and R. Wright, English Steel Corp. Ltd.

Water and air cool sand at George Fischer Ltd., Schaffhausen, Switz.
Dr. Franz Hofmann, Geo. Fischer Ltd.

Note casting model on pattern which is being placed on bed of "compo" at Eng. Steel Corp.

Applying "Chamotte paint" to "compo" mold for a 185 long ton crosshead casting in the foundry of Eng. Steel Corp. Ltd.
Dr. C. J. Dadswell and R. Wright, English Steel Corp. Ltd.

peated. Therefore, he relies on dry sand molding as a form of insurance.

Sand used for synthetic (compounded) mixtures is usually stained with a natural iron oxide. This does not condemn the sand, but rather improves its working qualities on certain castings and saves money in purchasing iron oxide. Most of the leading European foundries that employ synthetic (compounded) sand mixtures claim that better results are obtained when the molding sand is used at room temperatures. Sand coding devices using water and air to cool and dry system sand are popular. (Note Fig. 8.) Many use green compression strengths above 10 psi measured with standard European equipment. Most mixes have low permeabilities, less than 50 cc's per min.

On an average, European foundries use more new sand than North American foundries. They claim it is a safety factor to insure the pattern is well covered with all new facing sand when making the mold.

Contrary to certain opinions over here, one successful European foundry uses a base sand that contains as much as 25 per cent feldspar. It is a compounded sand grain and absorbs as much as six per cent water for proper temper. With six per cent coal dust (seacoal) and six per cent bentonite, it produces a casting as faultless as the writer has ever seen.

Many foundries are vacuuming the mold instead of blowing it out with an air hose. Less inclusions in the metal as well as less damage to the mold surface results when vacuuming the mold is substituted for the blast of an air hose.

Olivine Sand–Zircon Sand

In certain Scandinavian countries olivine sand is in use but not to the degree anticipated. It appears that zircon sand is a superior product. Evidently silica sand is equal to olivine and may be preferred, if there were no health laws or controls against the use of silica sand. However, where manganese steel is cast, olivine sands are doing a capable job. Economics again is the deciding factor in this selection. A considerable amount of zircon sand is being used in Europe but chiefly in the casting of steel.

Molding Sand Activities

The Europeans favor naturally bonded sands, fire clays and bentonites as molding sand binders. Some European calcium bentonites are treated with various alkalis and are being substituted for the Wyoming bentonites. Where they work properly they are considered to have an economic advantage over Wyoming bentonites. Some foundries, however, state this is false economy and do not care to use treated bentonites. The difference in initial cost is not always equal to the difference in the fettling (cleaning) room.

Not as much iron oxide is used in Europe as in North America, but more dextrine is used than corn flour. Lignin sulphite liquors and other waste products from the paper industry are also popular.

Few of the unknown compounded foundry materials are added to molding sands, but certain ground coal dusts blended with clay are being used.

Compo and Chamotte Molding

When an American visits Europe and realizes that most of the molding processes came from Europe, he expects to see more of them in operation. The Randpuson cement process, compo molding, chamotte molding, the Croning process, the lost-wax process, investment molding, the CO_2 process and numerous others originated in Europe but their use is not as widely spread as in North America. Only chamotte and compo molding are more in evidence.

Compo and chamotte molding are certainly not new processes but they are found throughout Europe for making large steel and gray iron castings. As stated previously, many heavy steel and gray iron foundries still employ an abundance of naturally bonded sand. Both compo and chamotte are generally used to replace naturally bonded sand for the casting of such heavy work, principally in the steel foundry. Compo and chamotte seem to be less sensitive to thermal shock from molten metal. Compo, in general use, is composed of approximately 70 per cent crushed scrapped firebricks, 15 per cent crushed chamotte grog, 14 per cent ground plastic fire clay and one per cent foundry blacking (graphite). A high temper water is added, equalling approximately ten per cent by weight.

Chamotte is usually a bauxite clay that has been pre-fired and calcined at about 1450 C. The refractory chamotte has a low apparent porosity. The chamotte grog should not break down into fines during crushing. It is screened and handled the same as silica sand in North America. Sand distribution is carefully considered in the preparation of this aggregate.

The mechanical testing properties for foundry use are similar to those of silica sand mixtures. Permeability is usually over 100, green compression strength usually over 10 psi, dry compression strength generally over 200 psi.

All molds made with these materials generally receive a chamotte or an alundum coating. The chamotte coatings vary in formulation but are approximately 80 per cent, or more, chamotte fines bonded with 10 per cent, or more, plastic fire clay. Certain other additives are used such as lignin sulphite liquors.

The best alundum mold paint observed was one containing 110 lb of alundum fines, 18 lb of ground plastic fire clay, 2 lb of western bentonite, 2 lb of dextrine with water to suspend. Approximately eight to ten gallons of water were used.

It is believed this ceramic type of molding should be further considered by North American foundries for casting certain large steel or gray iron castings.

CO_2 Process

A considerable amount of CO_2 molding is being employed, probably more so than other of the new methods. In common use are two new automatic CO_2 machines which blow and gas set the cores automatically.

Always economy conscious, the European has developed a unique technique in which a vacuum, or partial vacuum, is created in the core or mold boxes prior to gassing. After CO_2 treatment the excess gas is recovered. Saving this CO_2 introduces an economy into the op-

eration, as well as hardening the core more uniformly.

While visiting Dusseldorf, it was noted that a Congress was being held for Croning Process licensees. Some 150 foundrymen from six countries were in attendance. Opinions on shell molding expressed by those present were: "It is a good method to cast complicated patterns." "If it eliminates one or two cores, then it should be considered." "For complicated castings such as air-cooled cylinders with deep fins, that normally might be made in an oil sand core, it may be adopted." "Unless this process eliminates 100 per cent machining in certain critical areas, it might be too expensive."

The shell process is used most widely for coremaking. Royalty charges probably prohibit more European foundries from accepting this process. The European is sensitive to economic conditions that affect casting costs and carefully surveys the effect on the selling price of the casting.

Sand Control Testing

The European is more inclined to treat sand control as a tool of research and development, whereas the North American directly controls production from the sand laboratory. There are exceptions to this statement, as some of the larger operating foundries in Europe have carried sand control beyond a point of the laboratory and have actually developed their own sand-testing equipment.

A test widely accepted in Europe is the Shatter Index Test. In the test a rammed specimen drops 6 ft to an anvil on a 1/2-in. screen resting on base of apparatus. All particles falling through the screen are removed and the per cent remaining on the screen is the shatter index. There is a close relationship between green compression strength and shatter index for mixes with clay binder only. Organic binders rapidly increase the plasticity and therefore affect the shatter index considerably. There is much data established between shatter index test, sand grain size, grain size distribution and other compaction data.

Only a smaller percentage of European foundries use pop-off flasks or snap flasks. Tight metal flasks were being used instead. These flasks are built so rugged and are so heavy that handling tires the molder. In many cases these heavy steel flasks could only be manipulated by two operators when assembling the mold. Most flasks were cast from the metal being poured in the foundry. Not enough perforated metal flasks or lighter alloy flasks are in use.

Flasks and Bottom Boards

The thin slip flask was not widely used in Europe. Tapered boxless molding is claimed to have more difficulties for simplification of molding problems and for that reason it has lacked acceptance. Molds are sometimes handled many times. There is usually not sufficient room to handle too many molds, therefore they favor tight flasks.

Several companies were employing the use of old rubber tires to roll over heavy flasks and prevent the molds from being mistreated. Rubber tires appear to act as a better cushion than wooden posts and last longer.

Several economy-minded European foundries were protecting bottom boards by painting them with various solutions. To prevent burning of wooden bottom boards sodium silicate was painted over the boards. While still wet a very light coating of fine silica sand or silica flour was dusted over this sodium silicate. Drying bonded the refractory protective coating to surface of boards.

Also, on larger flasks certain foundries had made bottom boards from angle iron. One-half inch angle iron strips were welded approximately 1-in. apart to an outside border of 1-in. angle iron. A man could handle and easily stack these large steel bottom boards. Their service life was excellent.

Space limitations have required that this article be limited to a discussion of ideas and observations made on the subject of sand molding, handling and preparation. Some of the more spectacular European developments observed but not discussed concern the direct-reduction of iron ore to molten iron or steel; levitation melting and zone refining; inert gas welding; vacuum-arc melting; and vacuum-stream degassing.

The George Fischer universal sand testing machine is a versatile unit for performing compression, tensile and transverse tests.
Dr. Franz Hofmann, Geo. Fischer Ltd.

One of the most pleasant aspects of visiting foundries in another part of the world is the knowledge that foundrymen are the same, regardless of where they work. There is no foundry language barrier, discussions of cast metals being the same in all languages, with gestures a universal "tongue" in any country. A warm welcome always results when foundryman meets with foundryman.

The writer is deeply indebted to the courtesy and freedom of discussion accorded him wherever he went in Europe. The frontier barrier is ever present and necessarily prevents the ready dissemination of many technical advancements. Size, traditions, geographical position and changing languages naturally affects still further the rapid spread of foundry information as we know it in the United States. American foundrymen should realize, however, that European foundrymen do not consider themselves or their practice inferior to our own; in fact, in technological progress the foundries of Europe are indeed preparing for and looking forward to a bright future.

The Ridsdale Shatter Index Tester was developed by Ridsdale & Co., Middlesbrough, Eng., for green sand testing.

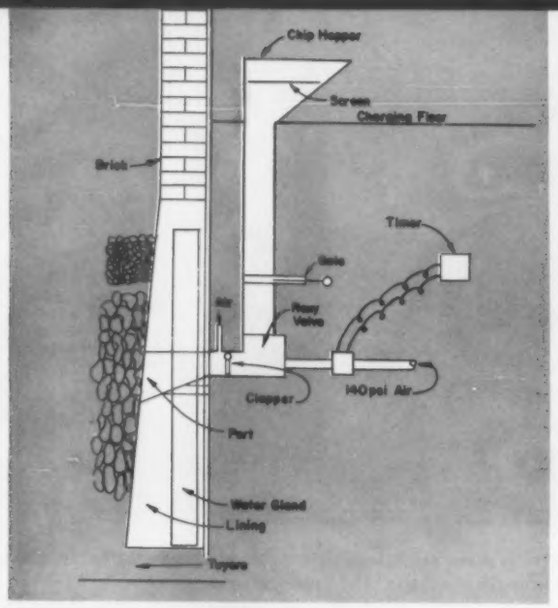
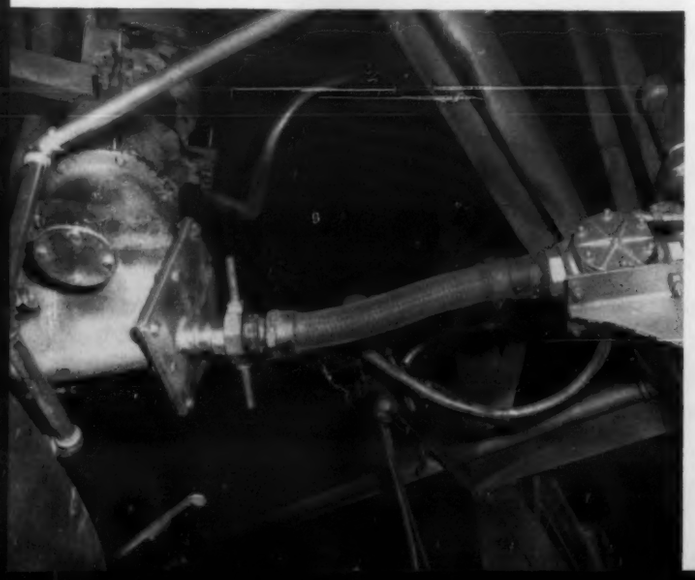


Diagram of Cadillac cupola boring injector shows essential components of installation used to melt loose chips.

CADILLAC shoots CAST IRON CHIPS into the CUPOLA

New boring injector installed to utilize low-cost machine-shop turnings in Detroit automotive foundry.

Air line, right, leads to Roxy valve on the left.



The injection of metal chips, or borings into the cupola melting zone by the use of compressed air is an innovation in the melting of iron that merits close examination.

This development is another product of German ingenuity in foundry practice and technique.

The first such installation in this country is now being evaluated in the foundry of the Cadillac Motor Car Division, GMC, Detroit.

In brief, batches of cast iron chips are blown at regular intervals into the cupola through a special port located and attached to the cupola shell at a height from the tuyeres approximating the upper level of the melting zone. It is reported that less coke is needed because heat is transferred more efficiently to borings than to cast scrap. Because of their great surface area, borings melt in a few seconds in contact with incandescent coke.

The basic components of the Cadillac installation are:

1) A hopper on the charging floor into which chips are dumped.
2) A vertical pipe, 10-in. diameter, leading down to a special valve, called a ROXY.
3) ROXY valve which controls the shooting action that delivers an accurate quantity of chips into the cupola.
4) High-pressure air line, timer and solenoid valve integrated to supply quick shots of air at regular intervals.
5) Port leading from the ROXY valve, through cupola lining, to melting zone.

A fork truck dumps chips from steel toter boxes into hopper on charging floor.

The hopper funnels the chips into a 10-in. diameter vertical pipe adjacent to the cupola. The pipe is 16 ft long, terminating at the ROXY valve and holds about 1000 lb of cast-iron chips.

Currently from 5 to 10 per cent of the charge is being injected in the form of cast-iron chips. Each shot weighs 7 to 9 lb. The driving force behind this 7 to 9-lb batch of chips is compressed air at 140 psi. A 2-in. pipe delivers this air to back of valve.

The frequency of shots may be varied from one every three sec to one every 10 sec.

At front of ROXY valve is a clapper-type valve. This valve is held closed by compressed air introduced in front of it at same pressure as cupola blast. Air stays on all the time and keeps hot cupola gases from entering and damaging the ROXY valve. When the high-pressure air line is opened every eight sec, sudden surge of excess pressure flips the clapper valve open and drives the chips into the cupola. The high-pressure air is cut off almost instantly by solenoid actuated valve. Low-pressure air line in front of clapper valve quickly slams it shut.

When the market value of chips is $58 per ton and pig iron and scrap are being quoted around $58 per ton, differential of $20 exists on every ton of chips consumed with 20 to 30 tons of cast-iron chips being used per 16-hr day, a savings of $400 to $600 a day is possible in raw material costs.

The equipment required for the operation and the installation per unit is relatively inexpensive—total cost less than $4500.

The availability of scrap could be an important factor that might influence your decision in such an installation. If your foundry is in an area where heavy melting scrap is scarce and expensive but machine shops are generating a copious supply of cheap turnings, an injector may prove a profitable addition to your cupola.

Injector mounted on cupola.

Steam Treating Cast Iron for CORROSION RESISTANCE

Steam treatment coupled with rust-preventative dip can replace chemical surface treatment

F. L. Spangler *and* M. E. Lackey
Leeds & Northrup Co.
Philadelphia

Fig. 1 . . Corrosion resistance of steam treated valve, right, is superior to cadmium plated sample, at left.

A relatively simple steam treatment of gray iron can literally "toughen the hide" on your castings against corrosive attack.

Steam treatment, usually followed by a dip in an oil or wax base rust-preventative, has been found highly effective and can often replace cadmium plating or other costly chemical surface treatment.

There are hundreds of uses for cast iron where a high degree of resistance to corrosion is extremely important.

The valve bodies in Fig. 1 are an interesting example. They are used in pneumatically-operated sanders which deliver controlled amounts of sand under the wheels of trains, street-cars or trucks to improve traction. Because of exposure to weather they must be highly corrosion-resistant. To obtain information on the effectiveness of steam treating these parts, sample lots were sent to an independent accredited testing laboratory for salt-spray tests according to A.S.T.M. standards. The valve on the left was cadmium plated, the one on the right, steam treated and dipped in one of the proprietary rust-preventatives. The valve on the left is shown as it appeared after 240 hours of the salt-spray test; the one on the right after 504 hours, at which time the test was stopped.

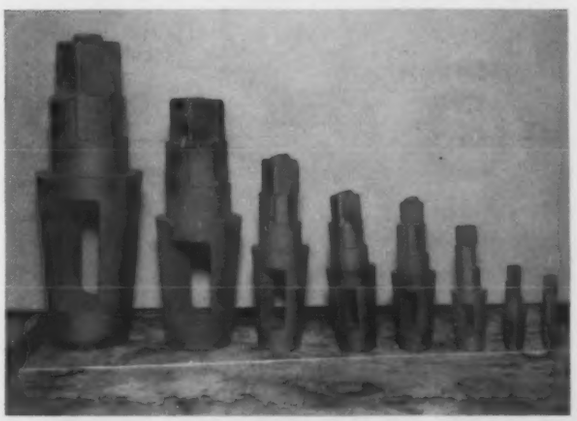


Fig. 2 . . Steam treated valve plugs withstand salt spray test for 72 hours without any oil dip.

The valve plugs in Fig. 2 are another example. They are steam-treated at 1200 F for 2 hours, then cooled and sent to the assembly shop where they are mounted into valve bodies with oil-impregnated packing. A.S.T.M. standard salt spray tests showed resistance to corrosion for 72 hours without oil dip.

Seals Microscopic Porosity

In applications where pump and valve bodies must withstand internal pressures from a liquid or gas, it becomes necessary to seal the casting against microscopic porosity to prevent leakage under operating conditions. Steam treatment has proved an effective, inexpensive solution to this problem and at the same time gives the part a pleasing, uniform, blue-black finish.

Preventing such porosity was the problem which initially led the manufacturer of the valves in Fig. 1 to install a steam-treating furnace. Rejects as high as 20-30 per cent due to porosity were not at all uncommon. Using the steam treatment, rejects because of porosity now run less than 1 per cent. Estimated savings on 1200 to 1500 parts is $1000.

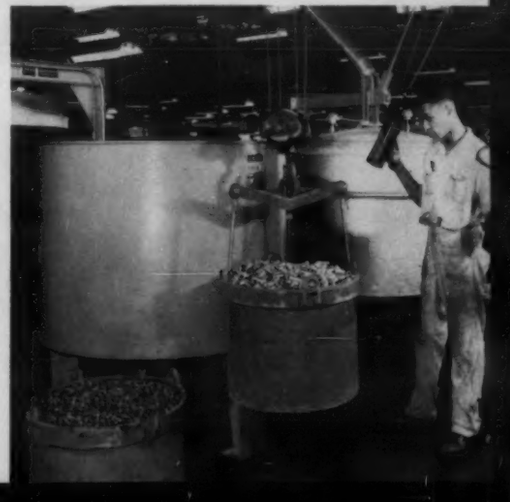
Improves Wear Resistance

Parts such as cast iron cams and bearings, valve tappets, pistons and piston rings derive better wearing-in properties from steam treatment. The cast iron automotive parts in Fig. 3 formerly required a chemical surface treatment for proper lubricating quality. Now this is obtained through steam-treating.

A tough, micro-thin, oxide-film, Fe_3O_4, deposited on all exposed surfaces of the casting during the steam treatment, is responsible for these benefits. This tightly adherent porous film retains lubricants and helps cushion parts while they lap into perfect fit during the breaking-in period. It also has, in itself, a high degree of corrosion resistance and its ability to retain lubricants enhances this characteristic as well as providing anti-frictional surfaces when the part is in service.

Equipment for the steam-treating process is safe, clean and easy to operate. An air-tight, forced-convection type furnace; a panel-mounted, automatic temperature controller and a reliable source of steam from a small generator or regular plant steam lines are all that are required.

Fig. 3 . . Lubricating quality of castings is improved by the treatment.



Auto Winners Named

Winners of the three automobiles given away in the drawing conducted by AFS at the AFS Show in Cleveland have been announced. The winners and the automobiles they won are:

Plymouth. Bryan McPherson, associate metallurgist, Southern Research Institute, Birmingham, Ala.

Mercury. Stanley Subko, supervisor, Burnside Steel Foundry Co., Chicago.

Pontiac. J. M. Kelly, Westinghouse Electric Corp., Trafford Foundry, Trafford, Pa.

The winners' names were the first three drawn from the simulated cupola in which the contest entrants placed their entry cards. The cards were mixed by an air blast in the cupola which was designed by Harry E. Gravlin, Chrysler Corp., Dearborn, Mich.

B. McPherson, left, is congratulated by Wm. W. Maloney.

The order in which the cars were awarded was determined by a separate drawing.

The drawings were conducted by AFS General Manager Wm. W. Maloney, and Assistant Secretary A. B. Sinnett. The chief guard of the Cleveland Public Auditorium, Harry Keegan, drew the winning names from the cupola.

Wm. W. Maloney announcing names of car winners drawn from cupola by Harry Keegan, left. A. B. Sinnet is at right.

Lucky foundry men drove these three automobiles away from AFS Foundry Show in Cleveland.

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RIGGING DESIGN OF HIGH STRENGTH MAGNESIUM ALLOY CASTINGS

By

Merton C. Flemings*, Richard W. Strachan**, Ernest J. Poirier** and Howard F. Taylor***

ABSTRACT

This paper describes the translation of laboratory results in simple test plate castings to the production of two high quality, production type magnesium alloy sand castings. One casting was composed of relatively heavy sections (1/2 to 2 in. thick) and the other of thin sections (1/10 to 1/2-in. thick). Both were cast of AZ91C alloy and AZ92A alloy.

The effect of judicious chilling on mechanical properties of the castings was examined. Chilling was found to substantially improve the properties of the heavy section casting in both AZ91C alloy and AZ92A alloy. For example, properties of the unchilled heavy section casting of AZ91C alloy averaged 24,200 psi ultimate tensile strength, 16,500 psi yield strength, and 1 per cent elongation. Chilling raised these average properties to 43,500 psi ultimate strength, 23,800 psi yield strength, and 3 per cent elongation. Similar improvement was obtained for AZ92A alloy.

Chilling was found to have little effect on the mechanical properties of the thin section casting. In this case the chill effect of the sand was adequate to produce mechanical properties nearly equivalent to those obtainable by heavy chilling.

INTRODUCTION

For several years the M.I.T. Foundry Laboratory has been engaged in a research program to determine optimum techniques for producing high quality castings for aeronautical and missile applications. Previous work has centered largely on techniques for casting aluminum alloys. For some aircraft uses, however, magnesium casting alloys have certain potential advantages; these include high strength-to-weight ratio and high stiffness-to-weight ratios. For these and other reasons, the desirability of adapting techniques for the production of uniformly high strength magnesium castings has become evident.

The work described herein is based on a previous laboratory study[1] of the effects of section size and chilling on the mechanical properties of sand cast test plates. In that study, careful control of melting and other foundry variables was maintained and alloys AZ91C and AZ92A were investigated. Mechanical properties of unchilled plates varying in section thickness from 1/4-in. to 1-1/2-in. were determined. The effect of end chilling these plates was also examined. It was found that chills markedly improved the properties of the heavier section castings (over about 1/2-in. thickness) but improved the properties of the thinner plates only slightly.

For example, chilling increased the tensile strength of the 1-1/2-in. AZ91C plate (near the chill) by 60 per cent. Even at a distance of 5 in. from the chill a tensile strength improvement of 45 per cent was obtained from the chill effect. In the thinner plates (less than about 1/2-in.) the chill effect of the sand was found to be sufficient to produce properties in the plates approaching those that could be obtained by chilling.

The present paper deals with the translation of the above laboratory results to the production of two prototype production castings. One of these castings was of thin section (less than 1/2-in.) throughout; chilling this casting was expected to result in little or no property improvement. The second casting was of heavier section, the section size varying from 1/2-in. to 2 in. Chilling this casting was expected to result in a substantial mechanical property increase.

PROCEDURE

The two gimbal castings shown in Fig. 3 and 5 were chosen for the present rigging study because of their size, reasonable complexity and variation in section thickness. The large gimbal (Fig. 3) is approximately 13 in. x 12 in. x 5-1/2 in. deep. Wall thickness varies from 1/2-in. to 2 in.; net weight is 15 lb. The small gimbal (Fig. 5) is approximately 3-1/4 in. x 2-1/2 in. diameter. Its section thickness varies from 1/10-in. to 1/2-in., and it weighs 3 ounces. Foundry procedures are described below:

1. *Chemical Control and Melting Practice*

Eight castings were poured from a total of six heats.

* Assistant Professor, Massachusetts Institute of Technology
** Research Assistant, Massachusetts Institute of Technology
*** Professor, Massachusetts Institute of Technology.

Alloys poured were AZ91C and AZ92A. Final chemical analyses of all heats are listed in Table 1.

Melting stock was composed of high purity virgin material and high purity remelt stock. AZ92A alloy (aim analysis–9% Al, 2% Zn, 0.15% Mn) and AZ91C (aim analysis–8.7% Al, 0.7% Zn, 0.15% Mn) were formulated. Virgin material used was magnesium pig (99.9%), aluminum pig (99.9%), zinc (99.9%), and aluminum-manganese hardener (75% Al, 25% Mn).

TABLE 1 – CHEMICAL ANALYSES OF EXPERIMENTAL HEATS

Heat	Casting	Chemical Analysis (%) Al	Zn	Mn	Si	Cu
a	AZ91C Alloy Chilled large casting	9.28	0.73	0.15	0.04	0.015
b	AZ91C Alloy Unchilled large casting	9.00	0.71	0.14	0.032	N.D.*
c	AZ91C Alloy Chilled and Unchilled small castings	9.35	0.76	0.17	T**	T
d	AZ92A Alloy Chilled large casting	9.28	2.09	0.19	—	—
e	AZ92A Alloy Unchilled large casting	9.14	2.11	0.17	—	—
f	AZ92A Alloy Chilled and Unchilled small castings	8.90	2.08	0.14	0.02	T

* N.D. – Not Detected
** T – Trace

Remelt stock consisted of returns from previous heats which had been remelted, pigged, and analyzed.

Melting was conducted in an open top gas fired furnace, using iron crucibles. In the melting practice of both alloys, the high purity remelt stock was charged first, and all elements except zinc were added shortly after meltdown. The zinc was added at 1250-1300 F. During melting, a commercial flux covering was maintained on the melt surface to prevent burning. Degassing was accomplished by bubbling chlorine through the melt for 10 minutes at 1330-1380 F. Grain refinement was obtained by superheating to 1650 F and holding for 15 minutes. Before pouring, the flux was skimmed from the melt and replaced with a light layer of sulfur-boric acid mixture. Molds were flushed with SO_2 gas immediately before pouring.

2. *Molding*

(a) Large Gimbal Casting

One large gimbal of AZ91C alloy and one of AZ92A were rigged according to techniques designed to produce optimum mechanical properties (but techniques which would be commercially practical). Essentially, the techniques involved placing chills and risers on the casting in such locations that mechanical properties in all portions of the casting would be raised substantially above the properties to be expected in a comparable normal sand casting.

The section sizes of the large gimbal vary from approximately 12 in. to 2 in. Previous work[1] has indicated that if chills and risers are spaced less than about 3 in. to 5 in. apart on such sections (for either AZ91C or AZ92A alloy), property improvement will result. From the standpoint of mechanical properties a minimum chill–riser distance is desirable, but from consideration of molding and cleaning difficulties a chill-riser distance of 2 in. is about as small as is feasible. Accordingly the large gimbal was rigged as shown in Fig. 1a and 1b, so that no portion

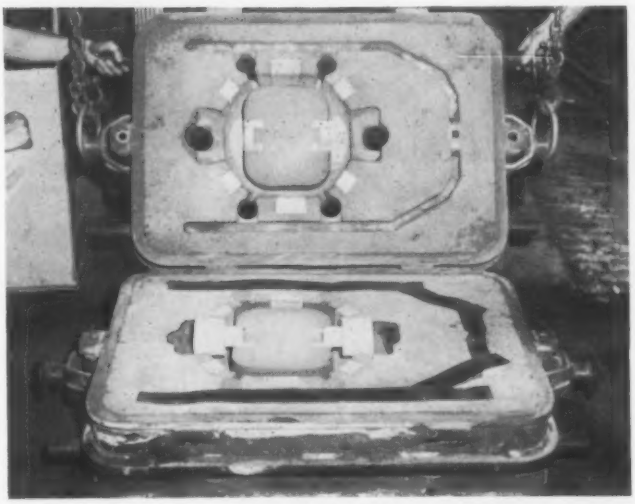

Fig. 1a–Mold (cope and drag) of high strength large magnesium gimbal.

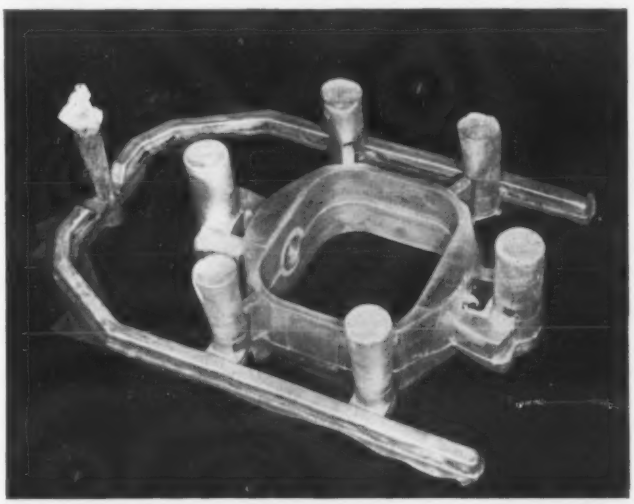

Fig. 1b–Casting at shakeout of high strength large magnesium gimbal.

TABLE 2 – SUMMARY OF FOUNDRY DATA FOR HIGH STRENGTH LARGE GIMBAL CASTINGS

Alloy:	AZ91C Heat a: AZ92A Heat d
Sand:	No. 80 AFS New Jersey Silica Sand, 4½% Southern Bentonite, 1½% Boric Acid, 1½% Sulfur, 1½% Diethylene Glycol, 3% Water
Risers:	No.: 6 Diameter: 4 on sides 2 in., 2 on heavy ends 2½ in. Height: 8 in.
Chills:	No.: 20 (10 in cope, 10 in drag) Total Wt.: 22 lb
Pouring Temp.:	1400 F
Type of Screens:	1/16-in. holes, 50% perforation
Sprue Dimensions:	1 in. x 1 in. at base
Runner:	1 in. x 1 in. in cope, 1 in. x ½-in. in drag
Gates:	No.: 4 (2 each side) Dimensions: 2 in. x ½-in.
Gating ratio:	1:4:3
Degas:	Chlorine, 10 min.
Gross Wt.:	40 lb
Net Wt.:	15 lb
Yield:	37½%

of the casting would be greater than 2 in. from a chill. The chills essentially "cut" the casting into a series of plates, chilled on one end and risered on the other.

Twenty chills having a total weight of 22 lb and coated with a talc-rosin wash were used. A gating ratio of 1:4:3 was used, with screens incorporated in the entire length of the runner to reduce dross entrapment in the casting. To insure a sound casting, risers were made overly large and a resulting low yield (37-1/2 per cent) was obtained. It should be possible, however, to improve this yield in subsequent castings on the basis of the results from these preliminary tests. Table 2 lists a more complete summary of foundry data relating to the two high strength large gimbal castings.

For comparison purposes the large gimbal was also made using more normal foundry rigging. One casting was made of AZ91C and one of AZ92A alloy with no chills incorporated in the mold. Figure 2 illustrates the molding practice and rigging used for both alloys. Other than rigging, the same foundry practices were used on these castings as on the castings rigged for high strength.

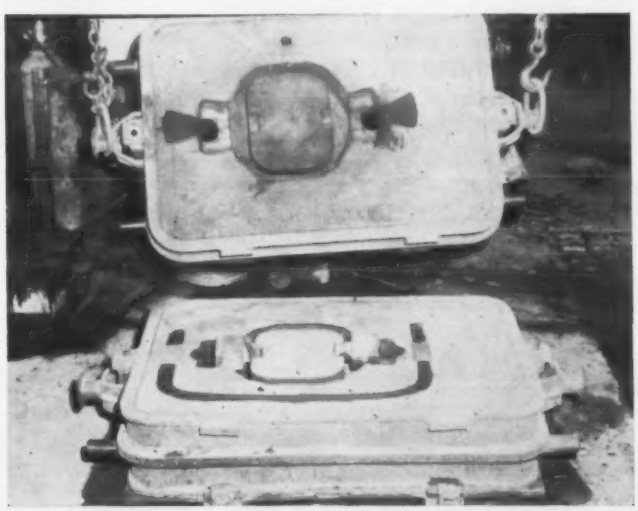

Fig. 2a—Mold (cope and drag) of commercially rigged large magnesium gimbal.

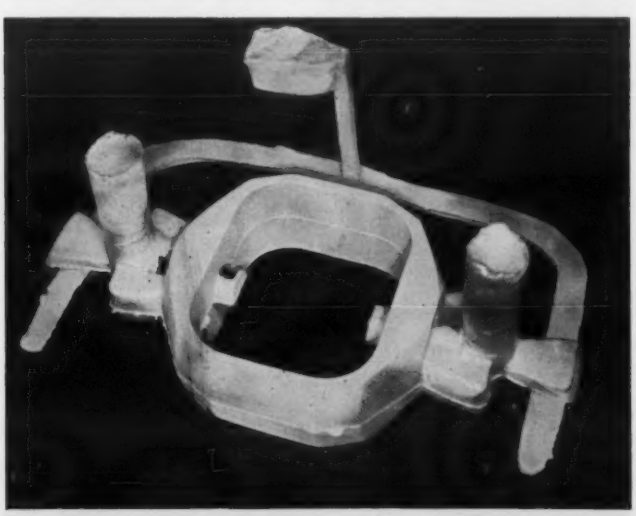

Fig. 2b—Casting at shakeout of commercially rigged large magnesium gimbal.

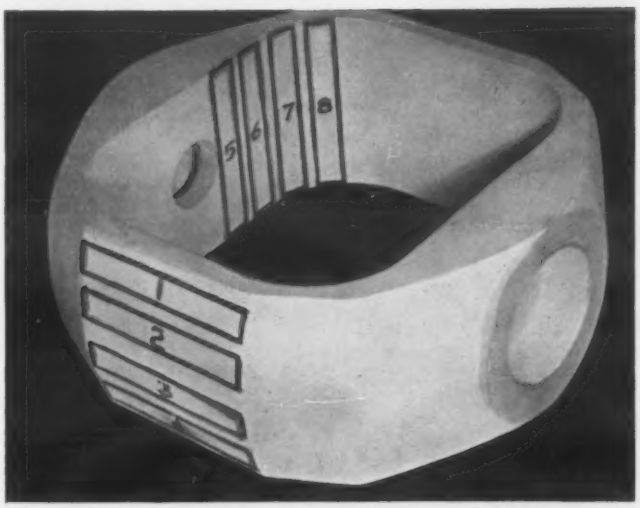

Fig. 3a—Test bar locations of large magnesium gimbal.

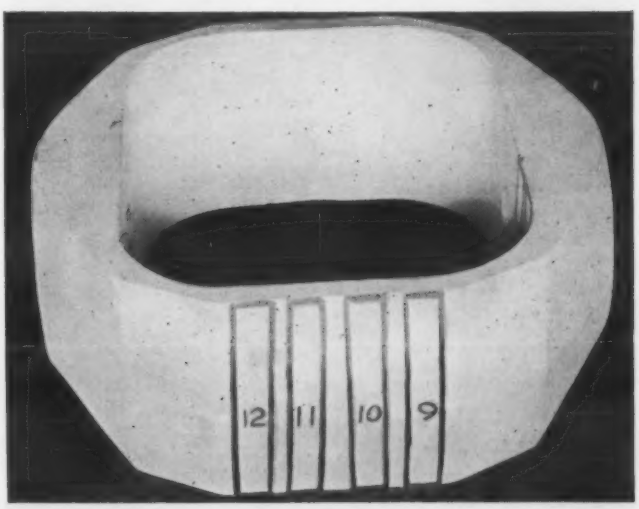

Fig. 3b—Test bar locations of large magnesium gimbal.

(b) Small Gimbal Castings

Section thicknesses of the small gimbal casting, shown in Fig. 5, vary from about 1/10-in. to 1/2-in. with most sections being less than 1/4-in. thick. Previous research[1] on simple flat plates has indicated

TABLE 3 — SUMMARY OF FOUNDRY DATA FOR HIGH STRENGTH SMALL GIMBALL CASTINGS

Alloy:	AZ91C Heat c: AZ92A Heat f
Sand:	No. 80 AFS New Jersey Silica Sand, 4½% Southern Bentonite, 1½% Boric Acid, 1½% Sulfur, 1½% Diethylene Glycol, 3% Water
Risers:	No.: 3 Diameter: 2 on ends 1½ in., 1 in center 1 in.
Chills:	No.: 4 (2 in cope, 2 in drag) Total Wt.: 4 oz
Pouring Temp.:	1550 F
Type of Screens:	1/16-in. holes, 50% perforation
Sprue Dimensions:	½-in. x ½-in. at base
Runner (in drag):	1 in. x ¾ in. to first gate, ¾ in. x ½ in. to other gates
Gates:	No.: 3 Dimensions: ¾-in. x ½-in.
Gating Ratio:	1:3:3
Degas:	Chlorine, 10 min.
Gross Wt.:	3 lb
Net Wt.:	4 oz
Yield:	8⅓%

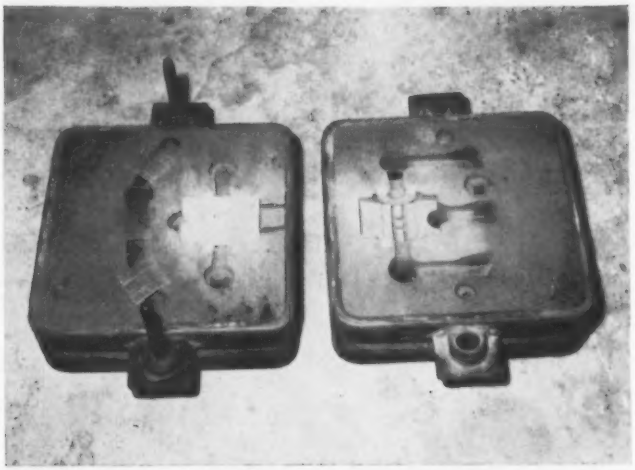

Fig. 4a—Mold (cope and drag) of small chilled magnesium gimbal.

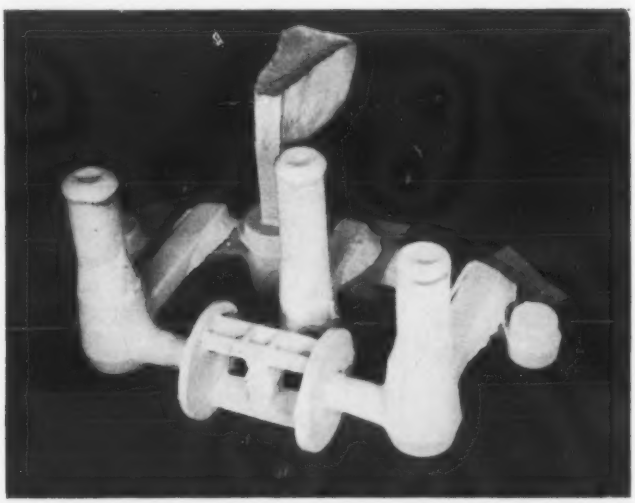

Fig. 4b—Casting at shakeout of small chilled magnesium gimbal.

that chilling a magnesium casting of such thin section would have no beneficial effect, but to ascertain this for intricate castings, two chilled small gimbals were poured. Figures 4a and 4b illustrate the rigging used. Chilling was accomplished by "doughnut" chills at the two casting extremities. The same rigging was used for AZ91C and AZ92A alloys. Table 3 lists a complete summary of foundry data for the chilled small gimbal castings.

For comparison, the two small gimbals were also poured with the same rigging as above but without the chills.

TABLE 4 – TYPE AND LOCATION OF TEST BARS IN LARGE GIMBAL CASTINGS

Bar No.	Section Size (in.)	Location	Distance from Chill (in.)	Distance from Riser (in.)	Bar Type
1	⅝	Beneath Chill (cope)	⅜	3½	0.505 Dia
2	1	Beneath Chill (cope)	⅜	3½	0.505 Dia
3	1	Beneath Chill (drag)	⅜	3½	0.505 Dia
4	⅝	Beneath Chill (drag)	⅜	3½	0.505 Dia
5	¾	Beneath Center Ring Chill	⅜	2	0.505 Dia
6	2	Between Riser and Chill	½	2¼	0.505 Dia
7	1½	Between Riser and Chill	¾	2	0.505 Dia
8	1	Between Riser and Chill	1	1¼	0.505 Dia
9	1¼	Between Riser and Chill	⅝	1	0.505 Dia
10	1¼	Beneath Chill	⅜	2½	0.505 Dia
11	1¼	Beneath Chill	⅜	2½	0.505 Dia
12	1¼	Between Riser and Chill	⅝	1	0.505 Dia

3. *Cleaning and Heat Treatment*

Cleaning of all castings was carried out without difficulty using standard equipment (but with special dust filtering in the sanding operations). A band saw, belt sander, and rotary hand sander were used; a final sand blast was given the castings before the photographs of Fig. 3 and 5 were taken.

The following heat treatment schedules were used for all castings:

(a) AZ92A Alloys
Solution Heat Treatment
2 hours at 665 F
6 hours at 765 F
2 hours at 665 F
10 hours at 765 F
Aging Treatment
4 hours at 500 F

(b) AZ91C Alloy
Solution Heat Treatment
2 hours at 665 F
6 hours at 775 F
2 hours at 665 F
10 hours at 775 F
Aging Treatment
16 hours at 335 F

After solution treatment all castings were air cooled and held for 24 hours before aging. During solution treatment an SO_2 atmosphere was maintained in the furnace.

4. *Physical and Mechanical Testing*

All castings were x-rayed to MIL-1-6865A specification. Casting soundness equaled or exceeded ASTM Reference Radiograph 1.1 No. 1; indicating all castings were entirely free of visible x-ray porosity.

After heat treatment, the test bar coupons sketched in Fig. 3 (large gimbals) and Fig. 5 (small gimbals) were cut from the castings and machined into tensile

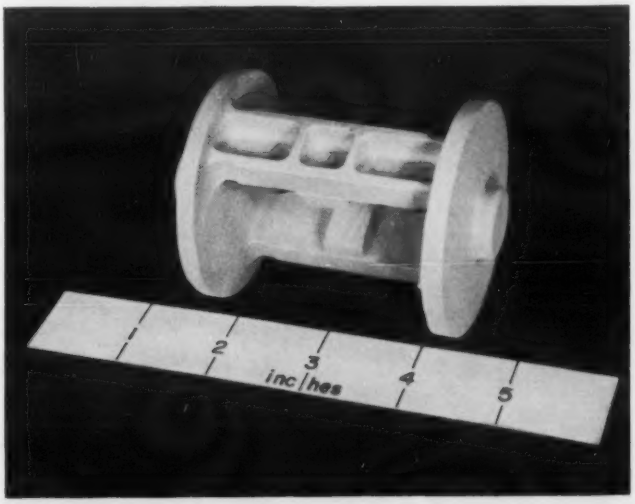

Fig. 5—Finished casting—small gimbal.

TABLE 5 – TYPE AND LOCATION OF TEST BARS IN SMALL GIMBAL CASTINGS

Bar No.	Section Size	Location	Distance from Chill (in.)	Distance from Riser (in.)	Bar Type (in.)
1	0.20	Center of Circular End (thin End)	½	½	¼ x ⅛
2	0.23	Center of Circular End (thin End)	½	¼	¼ x ⅛
3	0.10	Center of Section (cope)	1¼	¼	¼ x ⅒
4	0.10	Center of Section (drag)	1¼	¼	¼ x ⅒

specimens. Table 4 (for large gimbals) and Table 5 (for small gimbals) lists the size bar machined, the section thickness from which the test bars were taken, and the location of the bar with respect to chills and risers. The test bar locations were chosen as being representative of the casting as a whole; most other possible locations being similarly risered and chilled.

RESULTS AND DISCUSSION

Mechanical property data from all castings tested are listed in Tables 6 through 9. Table 6 presents the results of the chilled and unchilled large magnesium gimbal cast of AZ91C alloy. The table shows that

TABLE 6: MECHANICAL PROPERTIES OF LARGE MAGNESIUM GIMBALS, AZ91C ALLOY (HEAT A AND B)

Bar No.	High Strength (Chilled) Gimbal			Commercially Rigged (Unchilled) Gimbal		
	U.T.S. (psi)	Yield St. (psi)	% Elongation (in 2 in.)	U.T.S. (psi)	Yield St. (psi)	% Elongation (in 2 in.)
1	46,400	24,750	3	———	———	1
2	43,300	24,500	3	23,000	16,500	1
3	47,740	24,000	5	25,900	17,000	1
4	47,250	25,250	4	36,350	19,500	2½
5	43,700	24,000	2	20,950	14,750	1
6	34,900	21,500	1	20,400	13,750	1
7	44,100	25,000	3	24,550	16,500	1
8	40,650	22,000	2	24,950	16,500	1
9	37,750	22,000	2	22,200	16,750	1
10	46,100	25,000	4	23,100	16,250	1
11	44,650	24,200	3½	22,250	16,750	1
12	46,000	23,500	5	22,350	16,750	1
Average	43,500	23,800	3	24,200	16,500	1

the chilling used raised the average properties of large gimbal from 24,200; 16,500; 1 to 43,500; 23,800; 3.* Minimum ultimate tensile strength was raised from 20,400 psi to 34,900 psi by chilling, and minimum yield strength was raised from 13,800 psi to 21,500 psi. For the most part the properties obtained by chilling the AZ91C casting were equal to or greater than the properties that might have been expected from the test plate data previously described.[1]

As compared to the unchilled casting, the chilled AZ91C large gimbal casting shows an increase of 80 per cent in average ultimate tensile strength, 45 per cent in average yield strength, and 300 per cent in average elongation. Compared with present required minimums of 25,500; 14,500; 3/4 for AZ91C casting[2] the improvement is 70 per cent in ultimate tensile strength, 34 per cent in yield strength and 400 per cent in elongation.

* The shorthand 24,200; 16,500; 1 is used to denote 24,200 psi ultimate tensile strength, 16,500 psi yield strength, 1 per cent elongation.

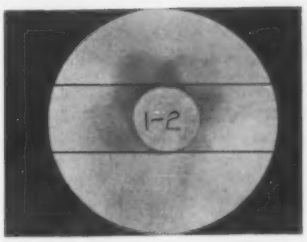

Fig. 6a–Test bar locations of small gimbal.

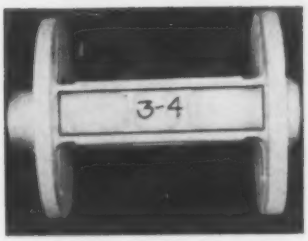

Fig. 6b–Test bar locations of small gimbal.

TABLE 7 — MECHANICAL PROPERTIES OF LARGE MAGNESIUM GIMBALS, AZ92A ALLOY (HEAT C AND D)

Bar No.	High Strength (Chilled) Gimbal			Commercially Rigged (Unchilled) Gimbal		
	U.T.S. (psi)	Yield St. (psi)	% Elongation (in 2 in.)	U.T.S. (psi)	Yield St. (psi)	% Elongation (in 2 in.)
1	39,500	21,100	3	35,500	21,100	1
2	40,750	22,000	4	25,050	18,250	1
3	39,350	23,500	3	23,100	18,000	1
4	41,800	21,500	4	29,250	19,000	1½
5	35,200	19,000	2½	20,200	16,250	1
6	36,900	———	3	25,050	18,500	1
7	38,900	21,500	2½	24,350	17,750	1
8	39,700	20,000	3½	27,200	18,250	1½
9	42,250	19,500	5	24,750	19,000	1
10	41,400	21,500	4	23,150	19,500	1
11	41,700	———	3½	23,000	18,250	1
12	40,050	20,250	2½	24,400	17,000	1
Average	39,800	20,900	3	25,400	18,400	1

Similar improvement was obtained by chilling the large AZ92A gimbal (Table 7). Here, average properties obtained were 39,800; 20,900; 3 in the chilled casting as compared to 25,400; 18,400; 1 for the unchilled casting. The average properties of the chilled AZ92A large gimbal represent an increase of 60 per cent in ultimate tensile strength and 30 per cent in yield strength over present minimum specifications of 25,000; 16,000; 0 for test bars cut from the casting.[2]

Mechanical properties of the chilled and unchilled small gimbals are listed in Tables 8 and 9. Chilling

TABLE 8 – MECHANICAL PROPERTIES OF CHILLED AND UNCHILLED SMALL MAGNESIUM GIMBALS, AZ91C ALLOY (HEAT C)

Bar No.	Chilled		Unchilled	
	U.T.S. (psi)	Per cent Elongation (in 1 in.)	U.T.S. (psi)	Per cent Elongation (in 1 in.)
1	44,200	2½	42,200	2½
2	43,500	2	25,900	½
3	39,600	½	34,700	½
4	35,400	½	43,300	2
Average	40,700	1½	36,500	1½

TABLE 9 – MECHANICAL PROPERTIES OF CHILLED AND UNCHILLED SMALL MAGNESIUM GIMBALS, AZ92A ALLOY (HEAT F)

Bar No.	Chilled		Unchilled	
	U.T.S. (psi)	Per cent Elongation (in 1 in.)	U.T.S. (psi)	Per cent Elongation (in 1 in.)
1	37,000	½	33,000	½
2	36,800	½	41,000	1
3	40,000	1	28,300	1
4	36,500	1	40,300	1½
Average	37,550	¾	35,650	1

TABLE 10 – MECHANICAL PROPERTIES OF CAST-TO-SIZE TEST BARS FROM EXPERIMENTAL HEATS

Heat	Ultimate Tensile Strength (psi)	Yield Strength (psi)	Per cent Elongation (in 2 in.)
A	42,850	23,500	3
	42,750	25,500	3
B	39,300	23,000	3½
	40,600	22,500	3
C	42,300	23,250	3
	41,000	22,500	3
D	36,500	19,000	3
	38,600	21,500	2
E	36,600	22,000	2
	38,750	21,000	2½
F	36,550	22,000	1
	35,550	21,000	2

of these castings resulted in very little net improvement of properties. The chill effect of the sand alone was sufficient to produce average mechanical properties in the small gimbals well above present minimum specifications. For example, the average ultimate tensile strengths of the unchilled castings of both alloys are about 40 per cent higher than present average acceptable minimum values.

SUMMARY AND CONCLUSIONS

The translation of laboratory results in simple test plate castings to the production of high strength magnesium alloy castings has been described. By judicious chilling of the heavier section castings and by careful foundry practice, the mechanical properties of magnesium alloy castings may be raised substantially above present design minimums.

In a heavy section AZ91C alloy casting (1/2-in. to 2-in. section size) the techniques described, including chilling, resulted in an average improvement of 70 per cent in ultimate tensile, 34 per cent in yield strength, and 400 per cent in elongation over present required design minimums. In a similar AZ92A alloy casting, the techniques resulted in 60 per cent increase in ultimate tensile strength, and 30 per cent increase in yield strength.

In the light section casting investigated (1/10-in. to 1/2-in. section size) chills were found to be unnecessary for obtaining optimum properties. Unchilled castings of both AZ91C and AZ92A alloys made with careful foundry practices were found to possess ultimate tensile strengths about 40 per cent above present design values.

ACKNOWLEDGEMENT

The authors wish to express their appreciation to the Instrumentation Laboratory, M.I.T., for support of this work through Air Force Ballistic Missile Div., Contract AF 04(645-9). Grateful acknowledgement is also due to a number of staff members of the Dow Chemical Co., Magnesium Dept., for their advice and support in many phases of the magnesium research program at M.I.T. The many technical bulletins published by Dow Chemical Co. on magnesium foundry practice have been a valuable source of technical information.

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SINTERED ALUMINA MOLDS FOR INVESTMENT CASTING OF STEELS

By
F. C. Quigley and B. Bovarnick*

ABSTRACT

An investigation was undertaken for the development of a new molding process for investment casting of steel alloys. The need for high refractoriness and low cost, coupled with processing requirements, led to the selection of aluminum oxide as the optimum mold material. A stable slurry was developed from alumina combined with binders and a wetting agent. The mold is formed by alternately dipping a wax pattern into the slurry and sprinkling the dip coat with coarse grain alumina until a built-up wall of desired thickness is attained.

The green mold is dried overnight in preparation for wax melt-out and firing. The melt-out is accomplished in less than 2 min, and the mold is fired at 2200 F for 25 min. After firing, the alumina molds have sufficient strength at 1200 to 1600 F to withstand the mechanical and thermal shock of pouring. High-quality castings of several alloy steels, 1020, 1030, and 4340, have been produced with good surface, metal quality, and dimensional control. These technical features and economic advantages of low cost and high speed indicate a high potential for the future use of sintered alumina molds.

INTRODUCTION

The search for improved precision casting methods and techniques has been a continuing activity by foundrymen for many years.[1] The current manufacture of precision castings of iron and steel alloys utilizing the lost-wax process is based on the two-coat investment mold. The two-coat investment has the basic disadvantage of requiring a heavy backup in support of a precoat and results in a bulky mold encased in a flask supported on a base plate. To obtain satisfactory molds, it is necessary to process them by long melt-out and firing cycles.

In recent years, investigations have been conducted to resolve the problems associated with the bulky investment. From these investigations, processes have been reported for the preparation of thin-walled molds with firing cycles of short duration.[1,2,3] Since Ordnance is vitally interested in precision casting of steel, a program was initiated at Watertown Arsenal to further develop the requirements and techniques for a low-cost thin-walled precision investment mold.

There is general agreement on the mold properties which should be optimized for efficient casting practice. Among these properties, the following were deemed basic to the objectives of this work. First, the process should result in thin-walled molds which would require short-time melt-out and firing cycles and would improve the cooling rate in the cast metal. It was essential that the mold have high strength to satisfy this requirement. To obtain the high strength economically, the mold material must be such that it could be readily sintered to the requisite strength levels.

Second, the major criteria for the mold material were that it be sufficiently refractory to permit the casting of metals that require pouring temperatures greater than 3000F; at the same time, the mold metal interaction be at a minium. An essential demand on the mold was that it be capable of withstanding the mechanical impact and thermal shock of pouring at the high temperatures.

Third, it was desired to accomplish pattern removal and sintering of the mold material (melt-out and bake-out) in a one-step operation for maxium efficiency. The initial melt-out was to be rapid enough to prevent the detrimental effects of wax expansion and permit wax recovery.

The measure of success of this program was that the process, as developed, be economically competitive with present investment processes. A manufacturing cost reduction, or a production rate increase, or a combination of these features should be realized.

MATERIAL SELECTION

The initial step was the selection of the mold material to conform to the criteria established. The first consideration was refractoriness. The material requires a softening point greater than 3000F. This placed it in the class of high-melting compounds. Availability and cost narrowed the field to graphite and two oxides, alumina and magnesia.

Since it is a requirement of investment casting that complex molds be produced, it was planned to form them by the application of slurries to wax patterns. The use of graphite was precluded because of the limited information on the processing of graphite in slip form. The choice between the two oxides was dictated by the great difference in the vehicle or medium with which their slips could be made. Alumina requires only ordinary tap water, but magnesia

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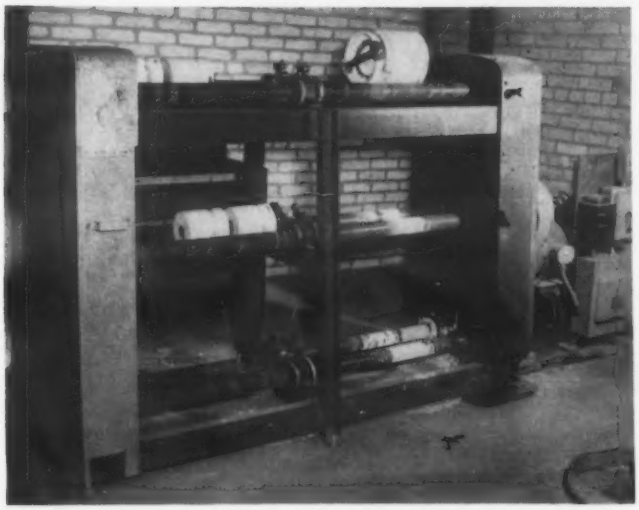

Fig. 1—Rolling Mill Used To Homogenize Slip. Watertown Arsenal—Rodman Laboratory.

needs alcohol. This necessitates precautions in handling and use, not to mention the difference in cost between alcohol and water.

Other properties of sintered aluminum oxide indicated that it had excellent prospects of meeting the strength requirements and related criteria.

1. It has high mechanical strength which allows the manufacture of thin-walled molds that could be readily handled during in-process operations.
2. Alumina can be readily sintered to satisfactory strength levels at practical temperatures.
3. Sintered alpha alumina, which undergoes no phase change on cooling, has good thermal-shock resistance.

PREPARATION OF SLIP AND MOLD

The next step was the formulation of a stable, workable alumina slip with certain desirable characteristics.

1. It had to be easily deflocculated and remain stable on standing.
2. It must readily wet the disposable pattern.
3. It required good coating stability.
4. It must have the ability to receive and bond a coarse grit for mold buildup.
5. A proper rate of water evaporation is required to prevent drying cracks.
6. It must have sufficient green strength.
7. It cannot crack during volitization of the green strength binder and wetting agent.
8. It should be readily sintered.
9. It should produce a good, smooth mold surface.

It appears that stringent demands have been put on the slip. Nevertheless, a slip formulation has been developed such that all of the above properties are realized.

The following slip constituents have been determined as the most satisfactory to date as the result of systematically controlled experiments: aluminum oxide, gum arabic, aerosol, ball clay, tap water, and hydrochloric acid. Acceptable grades of alumina should have a chemistry with a minimum aluminum oxide content of 99 per cent, iron oxide and soda less than 0.5 per cent each.

Should the iron oxide and soda contents exceed these limits, it becomes extremely difficult to stabilize the slip even with large amounts of hydrochloric acid. The powder should all pass through a 325-mesh screen and have a bulk specific gravity of 1.5 to 2. Powders of low-bulk specific gravity contain excess air, which tends to thicken the slip after long periods of rolling.

The crystalline structure of the particle should be alpha alumina, the stable, high-temperature phase. The ball clay, with fine grain and high plasticity,[5] was selected to lower the sintering point to within a practical firing range. The slip is composed of 75 per cent aluminum oxide, 0.6 per cent gum arabic, 0.1 per cent aerosol O.T. (100 per cent), 3 per cent ball clay, and the balance tap water.

The slip is best prepared by adding all of the dry material to the water in a porcelain mill jar. The jar is rotated on a rolling mill for approximately 2 hr Fig. 1). The mill is stopped and hydrochloric acid added, one ounce of a three normal solution for each 10 lb of slip. The slip is then rolled for 1 hr, again stopped, and sufficient acid is added to the solution to adjust the pH to approximately 3.4.

It is then allowed to roll for at least 20 hr to insure homogenization. Once the slip has been homogenized, further rolling is only necessary if it has been allowed to stand for more than 4 hr. The rolling need only be for 30 - 45 min to return the slip to its working consistency.

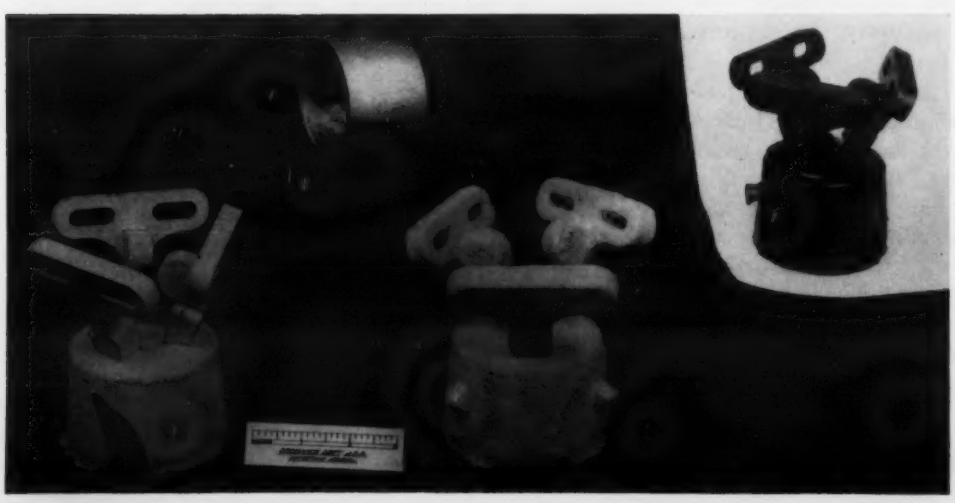

Fig. 2—Stages of Fabricating an Alumina Mold. Watertown Arsenal—Rodman Laboratory.

Slip life so far has not been determined. Slips one or two months old have been used with no noticeable adverse effects or deterioration.

The operation of forming a mold is relatively simple (Fig. 2). Wax patterns are mounted on a specifically designed hollow aluminum plug or tree, utilizing the common lost-wax procedure. There is no base plate attached to the plug. The setup is held by a 1/4-in. bolt that extends down 2-1/2-in. from the upper inside surface of the hollow plug.

The assembly is dipped into the slip and swirled to prevent the entrapment of air bubbles on the wax surface. The first dip coat is allowed to dry to a dull finish. This requires from 20 - 30 min to air dry, depending on the relative humidity and room temperature. After drying it is redipped. The wet, second coat is covered by sprinkling with a 60-mesh alumina. This operation is performed to increase the mold thickness and reduce the effects of thermal expansion.

Four or five successive dip coats are applied and, while wet, each is covered with the coarse grain alumina of 60 mesh and dried. Drying time between each of the coats is approximately 10 - 15 min.

The average time consumed in forming a mold is 2 hr. However, only 5 min of the 2 hr is labor time. The remainder is spent in drying between slip coats. The mold is then thoroughly dried by standing at room temperature for 8 - 12 hr prior to the melt-out and firing cycle.

MELT-OUT AND FIRING CYCLE

As has been stated, a one-step operation was desired for pattern removal and sintering of the mold (melt-out and firing) to promote maximum efficiency. A further advantage of the single-step operation is the prevention of mold failure or flaws which result from excess handling of molds before strength by firing has been developed.

The melt-out and firing can be done in high-temperature kilns or conventional furnaces, modified at low cost for the process. In the development work for this new investment casting mold, an experimental induction-heating furnace was constructed incorporating operating features considered essential for efficient quantity production. The original furnace was capable of firing only one mold at a time.

A larger furnace was constructed which could handle five molds. A 2400 F kiln has been obtained and modified to have a greater capacity. It is planned that, in future work, the melt-out and firing cycle will be carried out in the kiln to determine the efficiency and economics of firing molds this way.

The specialized features of the experimental furnace (Fig. 3) were: 1) uniform temperature zone larger than the over-all mold, 2) excess power capacity to bring the furnace to temperature in minimum time, 3) removable refractory bottom, and 4) tray for collection of the falling wax and plug.

The hollow aluminum plug was so designed to accelerate heat transfer to the wax-plug interface. This was to expedite release and fall out of the plug, which is accomplished within 20-30 sec. A coat of wax on the surface of the mold wall is left behind. The residual wax can then melt and run out smoothly without danger of tearing the green-mold wall.

The furnace temperature is brought up to and maintained at 2200 F for the entire melt-out and firing operation. After the mold has been properly dried, a soft iron-wire suspension is tied onto it. The removable refractory drawer at the base of the furnace is withdrawn. This gives an unobstructed path for the falling plug and molten wax from the hot zone to the collector tray.

The mold is suspended in the hot zone (Fig. 4) by hanging the wire support on a crossbar. The wire extends over the open top of the furnace and is externally supported. The plug and wax are eliminated from the mold in from 50-125 sec, falling into the tray for subsequent recovery.

At the termination of the wax elimination, the refractory bottom is replaced and the mold is fired

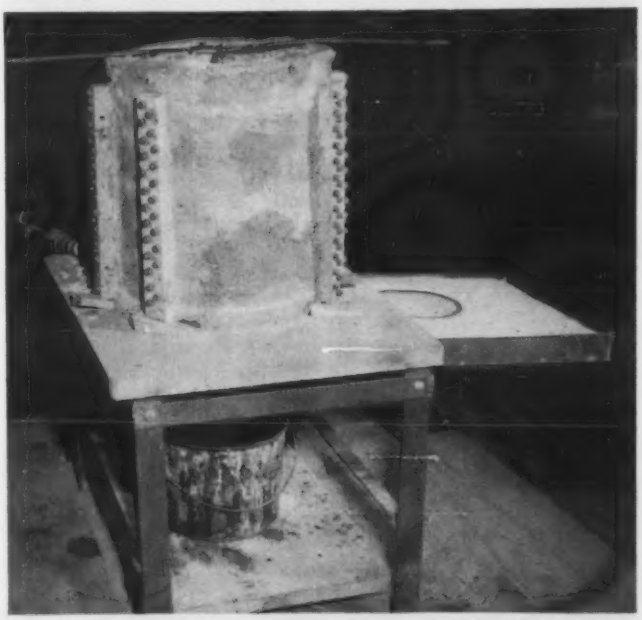

Fig. 3—Modified Induction Firing Furnace. Watertown Arsenal—Rodman Laboratory.

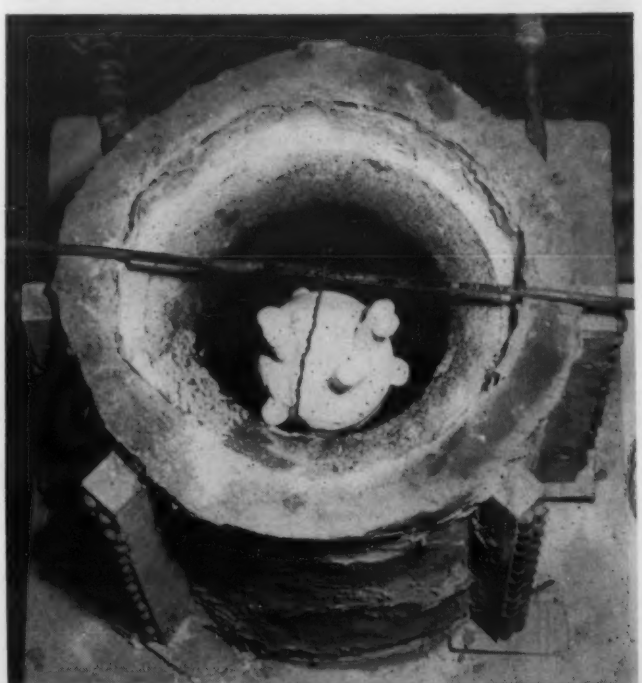

Fig. 4—Firing Furnace With Alumina Mold in Hot Zone. (2200 F). Watertown Arsenal—Rodman Laboratory.

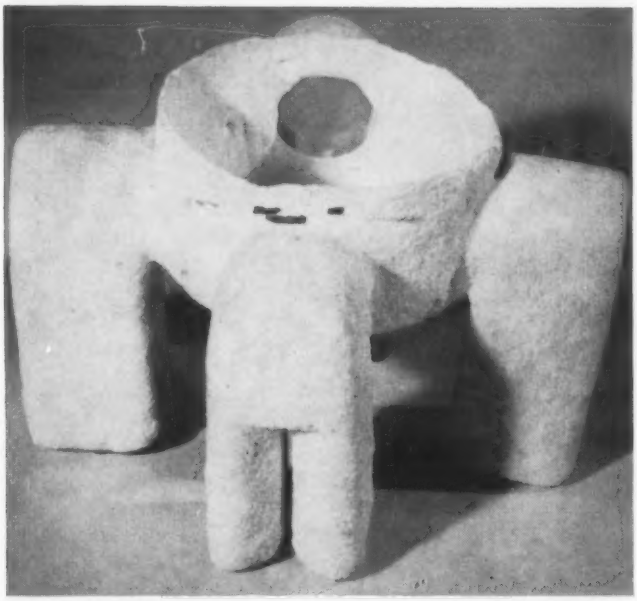

Fig. 5—A Finished Alumina Slip Mold. Watertown Arsenal—Rodman Laboratory.

Fig. 6—Mold Set Into Flask For Pouring. Watertown Arsenal—Rodman Laboratory.

at the furnace temperature of 2200 F for an additional 25-30 min. This firing period has been found adequate for sintering the green mold to satisfactory strength to withstand the pouring of the molten metal.

The sintered mold is taken from the furnace and allowed to air cool. The furnace is maintained at 2200 F to heat the next mold.

A close-up view of a fired mold (Fig. 5) illustrates the characteristics of these sintered alumina molds. The thin-wall construction, wax surface detail, absence of residual deposits from the wax pattern, and the rough external surface of the final grain coat.

CASTING OF METAL

The mold is now ready to receive the metal and can be cooled either to the desired preheat temperature for casting and used immediately, or to room temperature and preheated and poured later. It is not necessary to back up these molds, as they now have the strength to withstand the mechanical force and thermal shock of pouring the hot metal. They can be set into a flask or any other simple device for support.

Figure 6 shows a mold in a flask supported at the base of the pouring cup by two crossbars. It may be desirable to support molds for heavier castings at the bottom, as the mechanical impact of pouring greater amounts of metal may fracture the mold.

Typical parts which have been cast in thin-walled sintered alumina molds are shown in Fig. 7. In general, the castings were poured at 3100 F into molds pre-heated to 1600 F. The alloys represented by these parts are 1020, 1030 and 4340 steels. Because these parts were cast in a thin-wall mold, the shakeout problem associated with the bulky two-coat investment was not encountered. In all cases, the surface quality is considered to be equal to that of investment-cast Ordnance parts. There is no evidence of surface reaction between the metal and mold as is sometimes found in other ferrous investments.

In addition to the technical features of the process described, the desired economic advantages have been realized. Calculations, based on an anticipated production application, indicate that this process will produce a precision casting in two-thirds the normal

Fig. 7—Castings Made From An Alumina Mold. Watertown Arsenal—Rodman Laboratory.

elapsed time. Most of the time is saved in the melt-out and firing cycle which takes an average of 16-18 hr in the standard lost-wax method for casting steel.[1]

This automatically reduces power and fuel costs and increases the productivity of a given shop. There is also the elimination of flasks and bulky investments that have no shelf life. Thus, the development satisfies the fundamental criterion of success as stated at the beginning of this paper.

The work to this time has been concentrated on the manufacture of molds and pouring techniques. Work in progress is directed to the analysis of dimensional tolerances. Preliminary examinations indicate that there is good reproducibility of the wax patterns with only a few thousandths difference between castings. Metallurgical quality of the castings produced in the sintered alumina molds appears good and is currently under closer study.

SUMMARY

The development described in this paper offers several desirable features:

1. It is an easily formed thin-walled mold.
2. It has the high refractory qualities necessary for the casting of low alloy steels.
3. It possesses good mechanical strength requiring no backup in casting.
4. There is no evidence of mold metal interaction when casting.
5. The castings produced have good finish and are excellent reproductions of the wax patterns.
6. The process is economically competitive with existing ferrous investment casting methods.

These technical features and economic advantages indicate a high potential for the future use of thin-wall sintered alumina molds. However, it is to be noted that the results described in this paper have been accomplished with pilot-scale operations. No difficulties are foreseen in the up-scaling of the pilot methods to quantity-production operations.

To provide a basis to determine the reproducibility of the method, future effort is to be concerned with a statistical analysis of dimensional variation of the castings. Metallurgical examination of the castings for structure, decarburization, and physical properties will also be investigated.

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CARBON DIOXIDE CORES IN A MALLEABLE FOUNDRY

By

George Nestor*

INTRODUCTION

This is a progress report of experiences with the carbon dioxide or sodium silicate process. It reviews experiences with the process from the development stage to the present day when as high as 30 per cent of the daily core production is made by this method. The practice is economical, rapid, and space saving.

To prevent foundry scrap castings, such as hot tears, blows, and cracks, cores are required with low hardness, low gas content and good collapsibility. It is, therefore, necessary to consider these properties when formulating a sodium silicate core-sand mixture. It is also necessary to take into consideration the method by which the cores are made. The majority of our cores are made with a core blower; few are made on the bench or by hand.

EXPERIMENTAL WORK

In the experimental phase of the work over 50 different sand mixtures were tested using various ingredients, mulling cycles, and sequences of additions with little success.

Initial experiments were made by adding sugar or molasses to the sand mixture with little success. It was not until a specific grade of molasses was used that satisfactory cores were produced with a sand mixture containing a minimum of sodium silicate.

The results obtained in identical core-sand mixtures using two different grades of molasses are shown in Table 1.

When this process was first tried in our plant, little information was available pertaining to the CO_2 process. All that was known was that a sand mixture consisting of water, glass, and sand could be treated with CO_2 gas to produce cores for making castings.

The chief difference in the green properties of the two sand mixtures made with the two different types of molasses is in the green compression strengths (Table 1). A has a higher green compression strength than B. However, it is our opinion that green compression strength is of little importance since the cores are gassed in the box. The only strength that is then important is the gassed strength.

GASSED PROPERTIES

The analysis of the gassed properties of the two mixtures indicates the B mixture produces higher gassed tensile strengths. It also produces higher core hardness, has a lower moisture content, and produces less gas.

The cores made from mixture B (grade B molasses) could be handled, stored and used to make castings. The cores made from mixture A (grade A molasses) were too soft to handle and could not be used to make castings.

Table 2 notes the chemical analyses of the two different grades of molasses. Grade A contains only 57 per cent as much total sugar as grade B. Grade A has an ash content approximately seven times greater than the ash content of grade B. Grade B should be more effective than Grade A. Table 2 also shows that Grade A contains only 19.4 per cent invert sugar compared to 39.2 per cent invert sugar for Grade B.

It has been determined from a great many experiments that an ash content of less than 2.0 per cent is desirable. The ash is primarily lime which increases the viscosity of the silicate. This reduces its efficiency as a bonding agent.

We have not found any convincing or logical explanation as to the role that sugar plays in the CO_2

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TABLE 1 – MOLASSES

	A	B
Green Compression	1.37 psi	0.71 psi
Permeability	130.	136.
Moisture	1.7 %	1.7 %
Flowability	87.	82.
Tensile (after gassing)	14. psi	40.8 psi
Density	100.5	100.6
After gassing		
Moisture	1.4 %	1.23 %
Gas content	21.0 cc	16.6 cc
Hardness	.0	29.4

TABLE 2 – MOLASSES

	A	B
Sucrose	24.6%	38.0%
Invert Sugar	19.4	39.2
Total Sugar	44.0	77.2
Ash	10.7	1.6
Solids	77.2	*80.2

*Brix solids

process. It is known that sugar acts as a bonding agent and increases the gassed strength of the core. However, we believe its bonding strength is only incidental and quite minor in effect.

The sodium silicate used in our operation is a common commercial type having a soda to silica ratio of 1.0 to 2.4, and a Baume of 52. From our observations and experiments, a suitable core could only be obtained from core sand mixtures containing a minimum amount of silicate.

A careful study of the merits of the process had been made before any experiments or trials. From this study it was concluded that cores could be made economically only if quality cores could be produced at a high level of production. To determine if this was possible a high production automotive casting was selected for a trial of the process. A careful record of production, scrap, advantages, disadvantages, and other pertinent factors was kept.

One of the most annoying problems to be overcome was stickiness in the core box directly under the blow holes, and on the underface of the blow plate. Another problem was that of hardening of the core-sand mixture in the holes of the blow plate. Hardening of the core sand mixture in the blow chamber or magazine of the core blow machine was a concern.

A release oil was added to the core sand mixture to eliminate these conditions. This release oil was composed of 18 parts fuel oil to one part oleic acid. It was added at the rate of two ounces to every 100 lb of sand mixture. The addition of the oil acted as a lubricant as well as a retardant to the air setting of the core sand mixture.

CASTING SURFACE

The cored surface of the casting was not as good as the surface obtained from cores made with core oil or resin. Hence it was necessary to substitute 25 per cent bank sand for 25 per cent lake sand, with two per cent of iron oxide added. This mixture produced a casting surface comparable to the 100 per cent lake sand mixture containing core oil or resin.

It was then necessary to increase the silicate content of the sand mixture from 3.0 to 3.25 per cent to produce cores which could be handled. The iron oxide was added to reduce burn-on.

The sieve analysis of the sands used in making cores and molds by the CO_2 process is shown in Table 3. The bank sand aids in the production of a better finish. It also decreases the hardness to some extent. An excess of bank sand should be avoided since it apparently decreases the storage life of the gassed cores.

Table 4 shows the sand mixture which produces satisfactory results in our operation. Mulling times are kept at a minimum to retard temperature build-up. Mulling times may vary slightly with different types of mills.

The necessity for accurate weighing of the ingredients to maintain constant properties in the finished cores is of prime importance. Table 5 shows the results obtained in a typical CO_2 core-sand mixture and a typical core-oil core-sand mixture.

In our practice CO_2 gas is piped into the core room from a 12,000 lb capacity, low pressure, converter. All cores are gassed at 25 psi for from five to 10 sec. The CO_2 gas consumption varies between 50 to 70 lb per ton of cores. Core weights vary from a few ounces to 50 lb. For some unexplained reason it requires more gas to cure the small pin cores than the larger sized cores.

Correct gassing application has an important bearing on the rate of core production. In a two-box operation it is necessary to restrict the gassing time to a bare minimum, or it will decrease the rate of production. Increasing the gas pressure does not necessarily decrease the gassing time. In some instances to speed up the gassing time it was necessary to reduce the number of vents at the top of the box or increase the number of vents at the bottom of the box to facilitate the flow of gas through the core. In other instances it was necessary to reduce the volume of sand in the core by hollowing out the center of the core with a plug.

Figure 1 illustrates the effect of temperature of the sand on core weight. Experience has shown that when hot sand is used the air setting of the sand mixture is accelerated. This decreases workability. The loss of water through evaporation upsets the water-to-sodium silicate balance. This has a marked effect on the silica gel and causes it to lose its effectiveness as a binder. It is important to maintain the proper amount of water in the silica gel if maximum strengths are to be obtained.

TABLE 3 – SIEVE ANALYSIS

Lake Sand	Sieve No.	Bank Sand
.4	30	.2
4.5	40	.8
20.2	50	5.1
46.5	70	19.5
27.8	100	56.1
.6	140	15.9
.0	200	1.2
.0	270	.3
.0	PAN	.9
52.82	AFS Gfn	71.95
.13	% Clay	1.0
.26	% Carbon	.26

TABLE 4 – SODIUM SILICATE SAND MIX

450 lb	Lake Sand
150 lb	Bank Sand
6 lb	Sea Coal
12 lb	Iron Oxide
19 lb 8 oz	Sodium Silicate
4 lb 13 oz	Molasses
12 oz	Release
Mixing cycle—1 min	with dry ingredients
1 min	with Sodium Silicate
1 min	with Molasses
1 min	with Release

TABLE 5 – COMPARISON OF CO_2 AND OIL CORE SAND

CO_2 Core Sand		Oil Core Sand
0.66	Green compression, psi	0.79
126.	Permeability	105.
1.94	Moisture, %	2.46
(gassed) 38.	Tensile psi	(baked) 140.
33.	Scratch hardness	66.
1.33	Retained moisture, %	0.2
16.8 cc	Gas content	26. cc

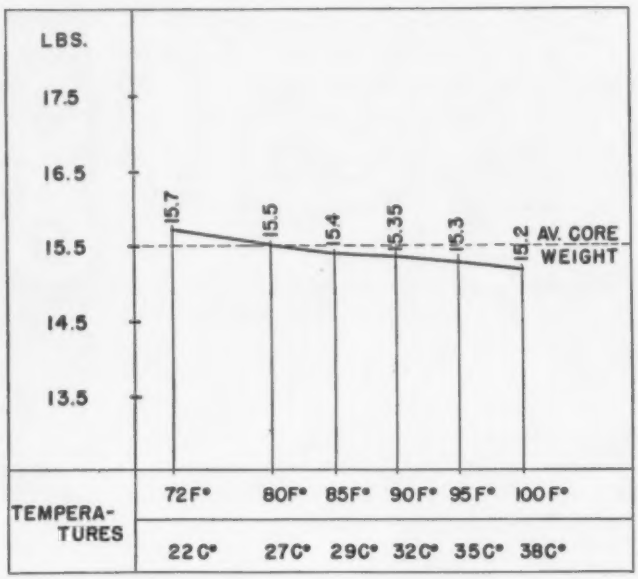

Fig. 1—Sand temperature core weight relationship.

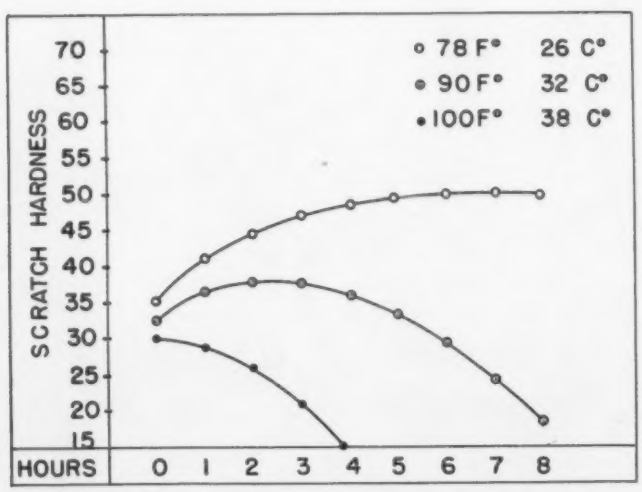

Fig. 2—Effect of sand temperature vs. core storage life.

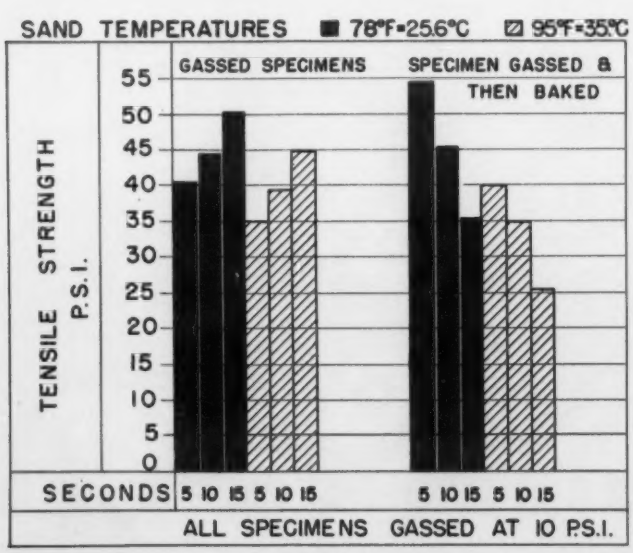

Fig. 3—Effect of sand temperatures on tensile strengths.

It will be noted from Fig. 1 that cores made from a core-sand mixture having a temperature of 72 F are about 0.5 lb heavier than cores made from a mixture at a temperature of 100 F. Cooler sand also has better blowability which aids in the production of a denser, heavier core. Satisfactory cores have been produced with sand temperatures as high as 85 F. There is a noticeable reduction in core quality and storage life if temperatures rise to between 86 and 92 F. Cores made with a sand mixture at over 92 F are poor and core breakage is high.

Figure 2 shows the effect of sand temperatures on core storage life. This graph shows that cores made from a sand mixture at a temperature of 78 F increase in hardness after air drying for 8 hr. It was deemed unnecessary to exceed 8 hr storage, since cores are seldom held over that period of time before using. Figure 2 illustrates that hot or warm sand is to be avoided if cores are to be stored for any long period of time.

Figure 3 shows the effect of sand temperature and gassing times on gassed tensile strengths. The cores were not gassed beyond 15 sec since our company does not gas over 15 sec in production. It will be noted that the tensile strengths increased with increased gassing times. However, on being heat cured the opposite results were obtained.

The heat cured tensile strengths decreased as the gassing time was increased. The same pattern is apparent with the higher sand temperature (95 F), but lower tensile strengths are obtained.

Figure 4 shows the effect of gassing time on core storage life. Low gassing time produces cores which increase in strength with increased storage time up to 24 hr. It also illustrates that the initial strengths increased with increased gassing time, but that the strengths decreased as the storage time was increased. Strength decreases rapidly in storage with increases in gassing time length.

Figure 5 illustrates the effect of elevated temperatures on the hardness of cores made from the CO_2 sand mixture noted in Table 4 with only one of the additives. The test was made to determine if core hardness could be correlated with core collapsibility. Standard 2 in. specimens were heated to the temperatures noted and soaked for the indicated times. Scratch hardness tests were made after the specimens had cooled to room temperature.

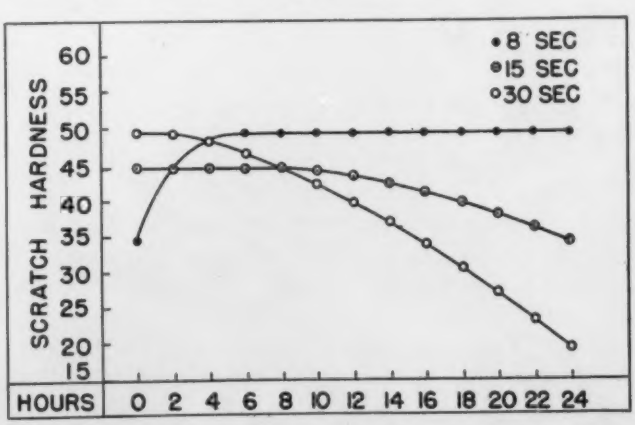

Fig. 4—Effect of gassing time on core storage life. Cores gassed at 25 psi.

The high level of hardness at 230 F is probably due to the dehydration of the sodium silicate. Investigators claim that sodium silicate produces its strongest bond when 2/3 of its original 55 per cent of water has been removed or evaporated.

The steady loss in hardness at 500 F, 1000 F, and 1250 F may be due to the start of fusion of the sodium silicate, and the start of the formation of glass. In all probability it is due to the effect of the sea coal and molasses. These retard the formation of a continuous film of glass on the sand grains.

At 1500 F all the sea coal and molasses have been destroyed, and fusion proceeds rapidly without retarding effects from these materials. Hardness increases almost to the point obtained at 230 F.

One theory advanced for the low hardness at 2000 F is that the sodium silicate is formed into globules at that temperature, no longer acts as a bond between the sand grains. At 2250 F to 2500 F the globules of sodium silicate start to react with the sand grains. Fusion of the sand grains takes place once more increasing the hardness.

Figure 6 shows the temperature-hardness relationship of the core-sand mixture being used at the present time. This mixture contains all the additives—sea coal, iron oxide, and molasses. It will be noted there is an absence of hardness at temperatures of 1250 F through 2000 F. It is not known why these three additives affect the hardnesses in this manner. Possibly it is because it prevents fusion of the sodium silicate.

At 2250 F all the additives have been destroyed permitting fusion of the silicate and sand grains. This mixture containing the three additives which produces the absence of measurable hardneses. At the temperatures of 1250 F through 2000 F it produces a higher level of hardness at the 2500 F than the mixture containing only one of the three additives. Attempts have been made to extend the minimum hardness beyond the 2000 F range, but so far they have met with little or no success.

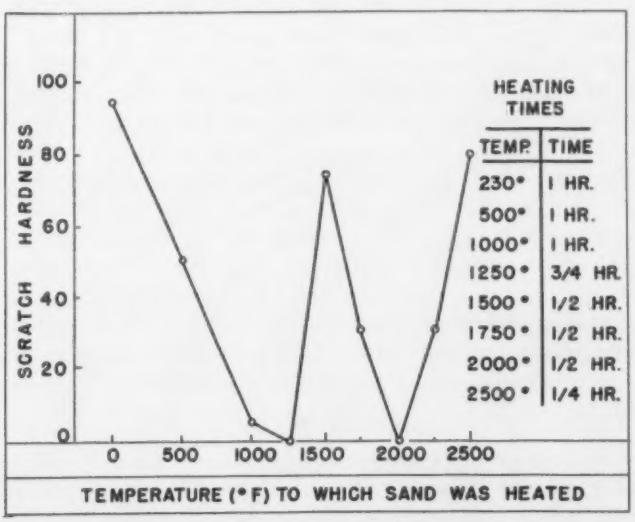

Fig. 5—Temperature-hardness relationship.

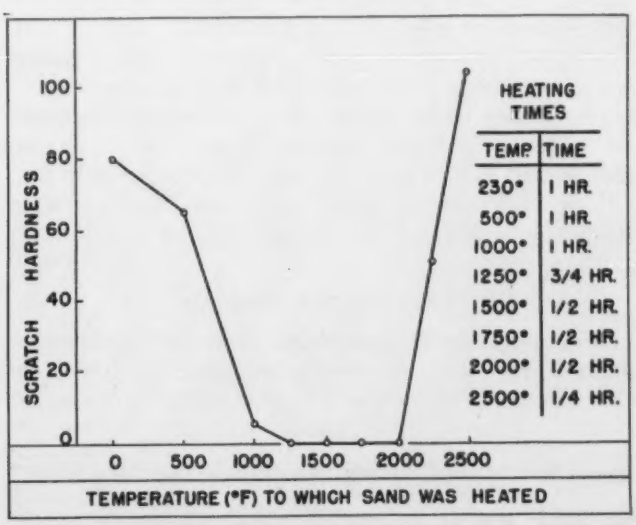

Fig. 6—Temperature-hardness relationship.

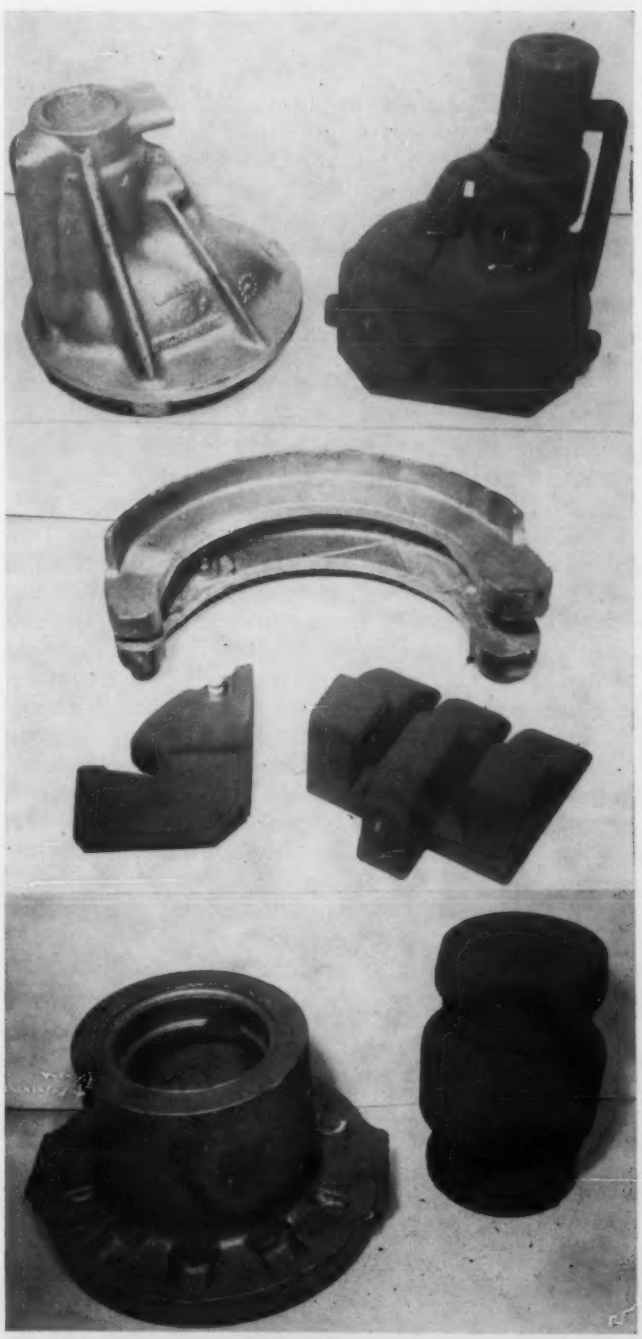

Fig. 7—Three typical cores and castings made with the CO_2 process.

Core collapsibility has not been much of a problem at our plant. Some collapsibility takes place at the shake-out. More takes place on the cooling conveyor. We have found that the rate of collapse is affected by the thickness of the metal surrounding the core, pouring temperature of the metal, and the length of time the castings remain in the mold. The collapsibility has been found to be at its maximum when the castings have been permitted to cool to room temperature in the mold.

The addition of the silicate sand to the molding sand has not had any noticeable effect on its properties. The same ranges have been retained on green strength, dry strength, green permeability, flowability and moisture. No marked affect on pH has been noted. It has had no effect on hard or soft scrap losses.

The CO_2 process has resulted in a savings of 20 per cent over the core-oil sand process. This is primarily due to the labor reduction in core handling.

Figure 7 shows three typical cores and castings made with the CO_2 process in our plant. All these cores were formally made with oil-sand cores.

PROBLEMS ENCOUNTERED IN CASTING REACTIVE METALS

By

W. A. Aschoff* and D. H. Blair**

The purpose of vacuum melting a metal is to provide a product with superior properties. By melting and casting reactive metals within a vacuum chamber oxygen and nitrogen contamination can be avoided, and purity can be improved by the removal of entrapped gases and volatile solids. Radial acceleration of the solidifying metal augments induced gas evolution with centrifugal castings poured in a vacuum chamber. The gas also forces lower density inclusions to float in toward the rotational axis where they can be more easily removed.

Although reactive metal castings are made commercially today, many problems of material handling still remain unsolved. The greatest difficulty, that of contamination by atmospheric gases, crucible, and molds, has received sufficient attention and research effort. Before we can expect to see wide spread application of castings of reactive metals like titanium and zirconium, there are many difficulties to be overcome.

GAS POROSITY

Gas porosity in the metal occurs as a consequence of employing vacuum melting to eliminate atmospheric contamination. In the case of titanium and zirconium, hydrogen or volatile chlorides are considered the major offenders. Oxygen and nitrogen may be present in a greater extent and are thought to remain dissolved within the metal.

Another source of these unwanted gases is possible volatiles driven out of the molds when contacted by hot metal. The most practical solution seems to be that of employing a lesser vacuum in the casting furnace than the metal has been subjected to in the prior melts, and in vacuum drying the molds prior to pouring.

VACUUM-ARC FURNACE

Probably the most satisfactory type of equipment employed for casting reactive metals is a water-cooled, copper-crucible, skull-melt, consumable-electrode, vacuum arc furnace as developed by the United States Bureau of Mines. However, in this furnace temperature measurement and control is practically impossible. Although thermocouples are available to cover some of the temperatures involved, these metals will become contaminated if the thermocouple well is placed within the molten pool.

Optical pyrometers cannot be employed during the melt because of the intense light from the arc at the surface of the molten pool. Probably the best answer to this would be to measure the stream of molten metal as it is poured from the crucible by a thermopile device. The reading of such an instrument will depend upon the emissivity of the molten stream. This, in turn, is dependent upon the surface conditions such as ripple, and splash.

No satisfactory answer has been reached, although we have great hopes for the thermopile device. However, this measurement cannot give us control of the molten-pool temperature. Since the molten bath is contained within a water-cooled, copper crucible, the power to maintain super heat is supplied from the consumable electrode arc. When that arc is extinguished the metal must be poured almost immediately. Therefore, present practice aims at controlling temperature and super heat by amperage and voltage control during the melting cycle.

Science gives way to art at this point where we are more dependent upon a good furnace operator than upon any other control which can be employed.

In addition to this problem of controlling temperature, we have no method of weighing a charge of molten metal prior to pouring. The entire contents of the water-cooled crucible must be poured immediately. The quantity of metal involved depends upon the artistry of the operator. This is true to a great extent because of the different characteristics encountered in melting in different designs of furnaces.

The geometry of the crucible—the rate of cooling, the relation of electrode size to crucible size, and partial pressure of inert gas within the chamber—all have a great effect upon the temperature of the melt. There still remain many unknown factors so we cannot predict accurately the results of any given pour until it has been tried. However, after a few runs a

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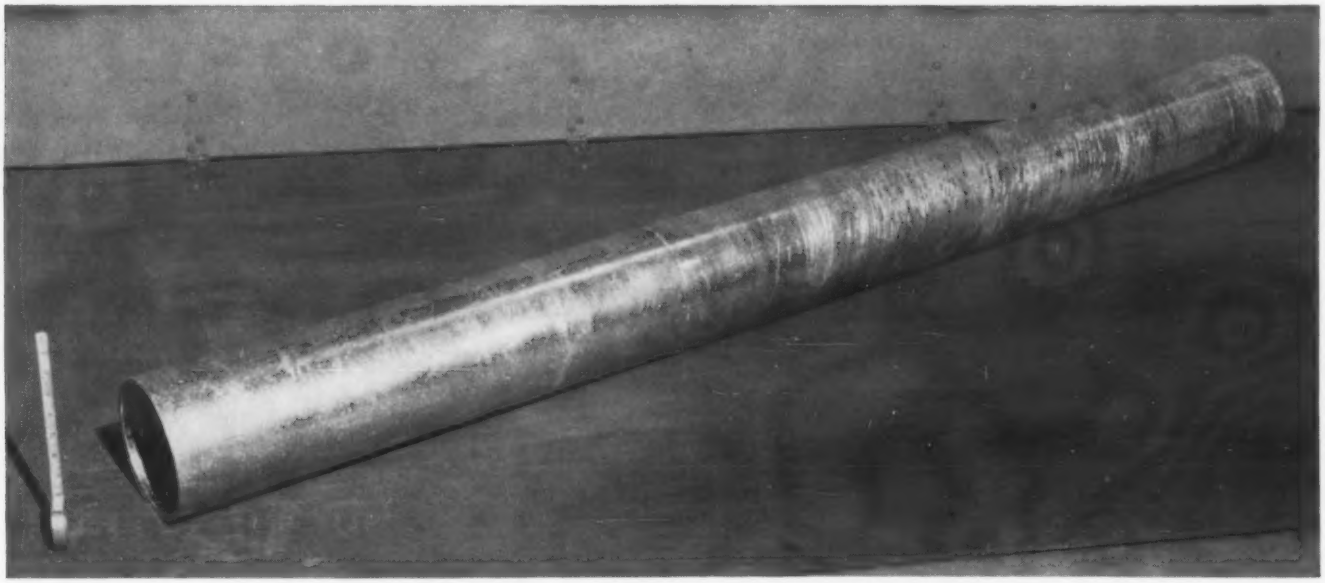

Fig. 1—Centrifugally cast pipe—6 in. diameter, 6 ft long titanium.

good operator should be able to pour metal at desired temperature and quantity within ±3 lb.

ALLOY-CASTING EFFECTS

Another field which still needs a good deal of investigation is the effect of casting various alloys. For example, an alpha-beta alloy, such as Ti 6A1-4V when poured into a chilled mold forms a needle like basket weave structure of crystals. To obtain the desired mechanical properties in casting an alloy of this type, vigorous heat treatment is required. This is because the as-cast metal has a yield strength of only slightly above half its ultimate strength.

The opposite extreme is exemplified by Zircalloy-2, an alloy of zirconium and nickel, with iron, chromium, and tin added. This alloy exhibits as-cast properties equivalent to wrought material with the exception of greater ductility. If these metals are to achieve commercial acceptance, casting alloys must be developed which will exhibit the desired properties of strength, ductility, and corrosion resistance with a minimum of heat treatment after casting.

Fig. 2—Two-in. titanium globe valve body cast in rammed graphite mold.

Some of the other reactive metals, such as molybdenum, niobium, and tantalum should find a ready market as cast shapes. Before we can cast these metals, we need more basic research on melting points, heat capacities, thermal conductivities, and purity required for as-cast ductility.

Molybdenum in the commercial purity available today exhibits absolutely no ductility in the as-cast state. In fact, it must be hot forged before any subsequent machine work can be done on it. However, studies by Gordon Poole at the Colorado School of Mines[1] indicate that molybdenum in the range of 3 ppm nitrogen, 10 ppm carbon and oxygen, is ductile in the as-cast state. Molybdenum of this purity is still practically unavailable so no experimental shape castings have been tried. This is another phase of the rare metals industry which should be pursued.

The availability of higher purity tantalum and niobium, and lower prices, will undoubtedly stimulate activity in these two metals as well.

Perhaps the so-called super alloys, both iron and nickel base, do not belong to the family of reactive metals. Results obtained by vacuum melting these materials indicate their behavior should put them in this class. Conventionally-melted material of this type shows improved mechanical properties after subsequent vacuum melting. The nearest approach to the maximum potentially available mechanical properties can be obtained by starting with extremely high-purity raw materials followed by vacuum melting.

A proprietary nickel-base alloy containing Cr, Co, Mo, Ti, Al, and Fe, for example, if air melted once, or made from other than the highest purity raw material will contain detrimental oxide inclusions even after two, or more high-vacuum remelts. This problem of oxide inclusions is prevelent in any of the super alloys containing more than 2 per cent titanium or aluminum. Oxide conclusions add to the brittleness encountered in the as-cast state.

Probably one of the greatest obstacles facing the reactive metal-casting business, is customer accept-

ance. One of the big factors involved here is cost. Using titanium, as an example, simple shapes as centrifugally-cast pipe (Fig. 1) can be made and sold profitably for as little as $8.00 a lb in the as-cast condition. The more complex shapes requiring extensive mold work may run as high as $100.00, $200.00, or $300.00 a lb, depending upon the unit size, quantity, and complexity involved.

With better materials, techniques, and equipment and increased volume, the cost of these castings is expected to drop to where they are competitive with other metals.

One of the major fields of possible cost reduction is in molds. Until recently machined graphite seemed the best material to give a casting not contaminated to a great extent, and produced to close dimensional tolerances. The material could be fairly easily worked. If the shape of the casting were right the mold gave reasonably long life.

Machined graphite was not a cheap mold to make since it had to be machined from solid material. In the case of cores or complex mold cavities containing re-entrant angles where the mold was pinched by solidifying metal, the mold was broken each time it was used to pour a casting, making the cost of the mold almost prohibitive.

Massive metal molds of copper, aluminum, and even steel have been used in many cases successfully. However, they have the same limitations we find in machined graphite.

A great deal of work has been done toward developing a rammable mold material which will not contaminate the metal castings. Probably the most successful consists of powdered graphite bonded with a carbonaceous binder. Fields, of Dupont, and Edelman, of Frankford Arsenal[2] have developed a mold material of this type which shows a great deal of promise. (Fig. 2)

A somewhat similar material has been developed by the United States Bureau of Mines. The molds of this type in certain instances indicate that the price of the finished article in any quantity will be approximately half of the price of a similar part made from machined-graphite molds and cores. There seems to be slightly more contamination in a rammed mix than is found in a machined graphite mold. This is not detrimental in many instances.

Shrinkage and warping encountered in baking these molds prior to pouring presents a problem where close tolerance castings are required. In cases where close as-cast dimensions are not required the rammed mix does offer many advantages in the cost of the finished product and in the production speed.

If the machined-graphite molds can be reused 10 or more times, generally they will be cheaper than rammed graphite. The greater ease of gating and risering possible with the rammed material may prove more important than the cost alone.

SCRAP UTILIZATION

Another excellent opportunity for possible lowering of costs lies in utilizing scrap material for melting stock. There is a need for better methods of recycling gates, risers, and scrap castings with a minimum of labor and no deterioration of metal quality.

Another item which needs attention in cost reduction is in a better and cheaper method of cooling the castings rapidly within the vacuum furnace without employing the inert gas now in use. Although this seems to be a minor item, it can account for as much as $1.00 a lb added to the price of the final product.

It is important that these castings be cooled rapidly, since a furnace containing castings in the mold is inoperative. An idle furnace is not a money maker. Again using titanium as an example, castings must be cooled to about 1200 F before they can be exposed to air if surface oxidation is to be avoided. The fastest cooling method of these reactive metals is to back-fill the vacuum furnace with helium gas. If this gas could be salvaged and reused the savings could be tremendous.

Sales resistence on the part of prospective customers is a major obstacle which still remains. Until this obstacle is overcome, castings of reactive metals cannot be made on a mass-production basis.

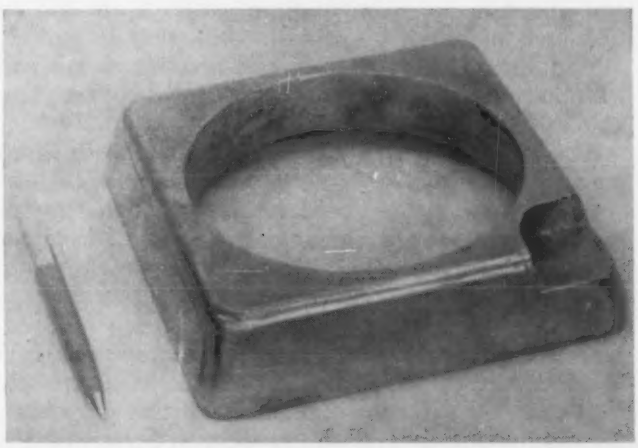

Fig. 3—Cast zirconium alloy reactor part.

Fig. 4—Zirconium pipe, centrifugally cast, for redraw into thin-wall tube.

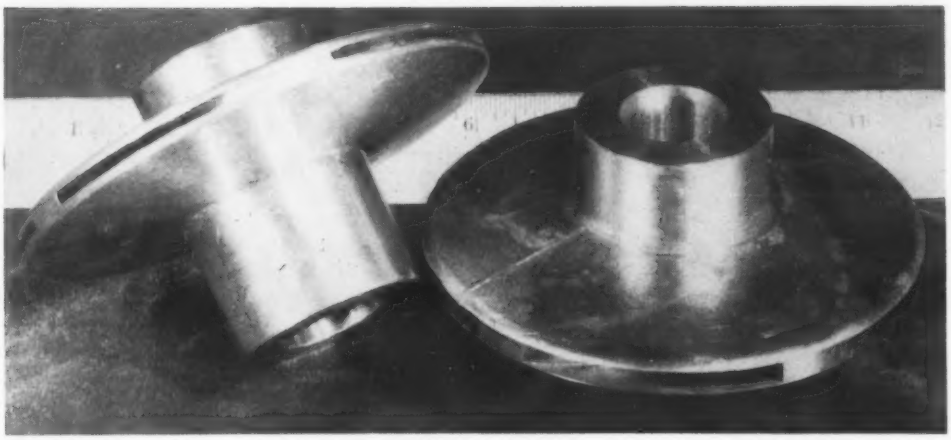

Fig. 5—Cast titanium one-piece shrouded centrifugal pump impellers.

Education is needed to convince prospective buyers of the advantages of vacuum-melted, cast-reactive metals. Although many are familiar with the corrosion resistance and mechanical properties of these metals and alloys in the wrought form, castings are still an unknown quantity.

Widespread application of cast reactive metals will continue slowly until more general knowledge is available and disseminated upon their properties.

A second phase of this sales problem concerns making known the availability of shape castings. Those which are either more economical to produce by this method, or shapes not practical to produce by other methods. Two entirely different types of zirconium castings serve to illustrate this last point.

The first is a static-poured shape casting of zirconium alloy used in a thermal nuclear reactor (Fig. 3). The part produced by casting exhibited entirely satisfactory strength and corrosion resistent properties. Its cost was less, and the percent recovery of the rather rare and expensive zirconium metal was much greater than comparable parts made either by machining from solid material or from forgings.[3]

A second illustrative item is a centrifugally-cast zirconium pipe (Fig. 4) from which thin-wall tubing may be drawn. In atomic-power reactors, the cost of zirconium tubing can be a major item. Such a large item that in many cases it is more economical to use stainless steel tubing and go to a higher enriched fuel than to use the more expensive zirconium tubing.

If this tubing is made from redrawn centrifugally-cast material, its cost should be lowered sufficiently. The economic balance between tube efficiency and cost, and fuel element cost should swing to zirconium tubing. This tubing requires less potent fuel than stainless steel.

Items such as one-piece, completely-shrouded, centrifugal pump impellers (Fig. 5) serve as a good example of shapes which cannot be produced by means other than casting. These parts are now available. The prospective customer must be made to know they are available, and that they can be made at a reasonable price.

SUMMARY

Before shape castings can be expected to occupy the quantitative position they deserve in the reactive metals field, we must solve the questions of gas porosity, and temperature control. The problem of what to do with conventional alloys, heat treatment, and developing better alloys specifically for casting must be solved. The problem of better and more efficient methods of making these castings to reduce cost, and of selling the prospective customers on the advantages and availability of these shapes must be answered.

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2. October, 1956 *Metal Progress*, and May, 1957, MODERN CASTINGS.
3. Report WAPD-NCE-4860 "Evaluation of Vacuum Cast Transition Pieces for PWR Core 1 Blanket", E. G. Schwartz and W. L. Frankhouser, Westinghouse Atomic Power Dept., Bettis Field, Pennsylvania. Report provided by Mr. Lawton D. Geiger, USAEC.

THE PROBLEM OF HOT MOLDING SANDS

By

R. W. Heine,* E. H. King,** and J. S. Schumacher***

INTRODUCTION

In some foundries, molding sand may be used a number of times during each molding and pouring period. As the sand is reused for molding, its average temperature rises because of heat input of the metal poured into previous molds. After being reused several times a fairly stable temperature above room temperature is attained by the sand at the point of the molding operations.

Thus, the first molding in a work period is done with ambient temperature molding sand of about 50 to 85 F. The later molding is done with sand at a consistently higher temperature, such as 100 to 160 F. The higher molding-sand temperatures have been suspected of having a harmful effect on molding sand properties. These temperatures were suspect in impairing the sand molding behavior, and causing casting defects.

Numerous foundrymen have shown positively the relationship of rise in temperature of the molding sand to an increase in casting defects and difficulties in molding with the hot sand.

EFFECT OF TEMPERATURE ON SAND CONTROL PROPERTIES

As a starting point, it is important to know whether some properties commonly measured by sand control tests are altered significantly by increasing sand temperature in the range of 60 to 160 F. The following experiments were carried out:

A standard 18-in. D vertical-wheel muller was run at 42 rpm and equipped with electrical heating elements and thermal insulation. This was so the temperatures of the muller parts in contact with the sand could be maintained at a particular temperature above room temperature. Molding sand was heated to the temperature being studied, and charged into the muller at the same temperature. Water was added immediately and the sand was mulled for six min at this temperature.

The sand was riddled through a No. 6 sieve into an insulated, preheated container. Container and sand were placed in an oven held at the temperature being studied. All sand testing equipment which might contact the sand was heated in the same oven to avoid heat loss to the specimen tube and compression plates.

Standard 3-ram specimens were prepared and tested as rapidly as possible. Moisture determinations were made on broken green compression specimens. Using this technique, the effect of sand temperature on some properties of several sands was determined.

Table 1 presents data relating some properties to temperature for a new sand mixture composed of 8.0 per cent southern bentonite, and 92 per cent 85 AFS, 4-screen sand. Table 2 presents similar data for

TABLE 1 — COMPARISON OF SOME STANDARD 3-RAM PROPERTIES OF A SOUTHERN BENTONITE BONDED SAND AT ELEVATED TEMPERATURE AND ROOM TEMPERATURE*

Temperature F	% H_2O	Green Compressive Strength, psi	Dry Compressive Strength, psi	Av. Mold Hardness
60	4.20	12.5	100	85
90	4.20	12.7	92	85.5
60	3.30	18	56	89
122	3.30	19.5	48	89.5
60	3.0	21.0	44	91.5
122	3.0	21.0	40	92

*8.0 per cent southern bentonite, 92 per cent 85 AFS, 4-screen sand.

TABLE 2 — COMPARISON OF STANDARD 3-RAM PROPERTIES OF A WESTERN BENTONITE BONDED SAND AT ELEVATED TEMPERATURE AND NORMAL TEMPERATURES*

Temperature F	% H_2O	Green Compressive Strength, psi	Dry Compressive Strength, psi	Av. Mold Hardness
60	3.0	24.0	52	91.5
90	3.0	23.0	47	91.0
60	3.8	16.0	142.0	86.0
122	3.8	15.7	132.0	85.5

*8.0 per cent western bentonite, 92 per cent 85 AFS, 4-screen sand.

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**Vice-President, The Hill and Griffith Co., Cincinnati, Ohio.
***Chief Engineer, The Hill and Griffith Co.

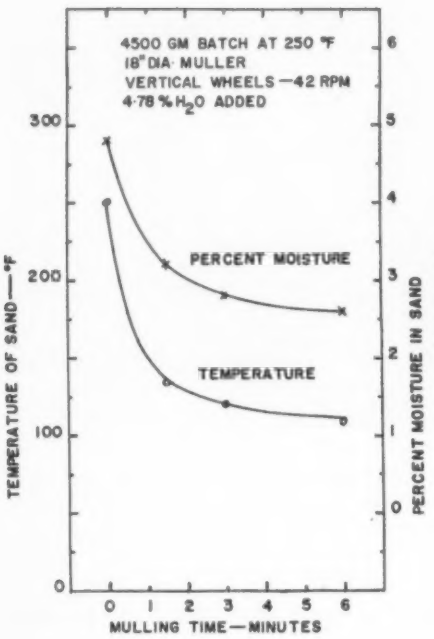

Fig. 1 — Effect of mulling time on temperature and per cent moisture of hot sand charged into muller at 250 F.

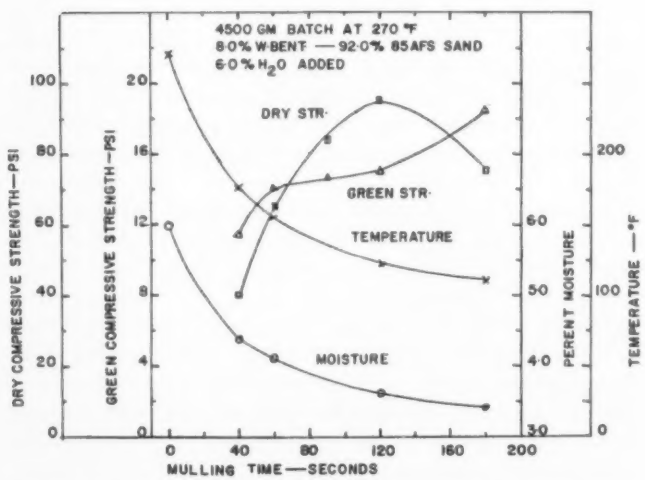

Fig. 2 — Effect of mulling time on temperature per cent moisture, green strength and dry strength of hot sand charged into muller at 270 F.

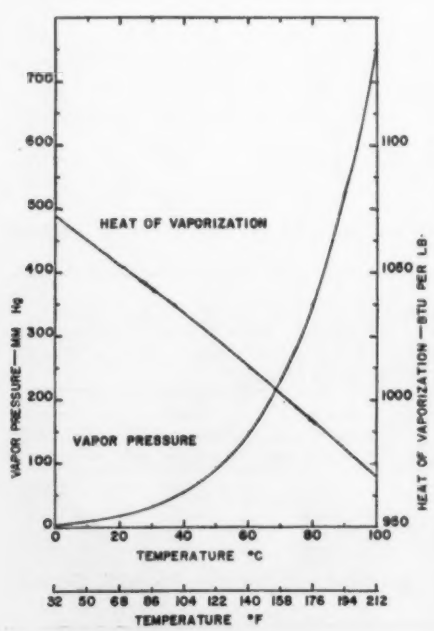

Fig. 3 — Effect of temperature on vapor pressure and heat of vaporization of water at one atmosphere.

a new sand mixture of 8.0 per cent western bentonite, and 92 per cent 85 AFS, 4-screen sand.

These sands were mulled with tempering water at room temperature for 10 min. They were then dried at 220 F, and heated to the temperature being studied and mulled with water. The data presented in Tables 1 and 2 represent a thoroughly mulled sand condition. This point must be recognized.

Examining the data in Tables 1 and 2 indicate no substantial differences between elevated temperature sand and room temperature sand. This is as far as green and dry-compressive strength, and mold hardness at a given percentage of moisture. There is an indication of about a 5 to 10 per cent drop in dry strength at the higher temperatures. This is not regarded as being really significant.

Several foundry sands and new fire-clay bonded sands were tested in this way. The results were similar to those above for Tables 1 and 2. The results reported are believed to be applicable to most foundry sands for the properties and temperatures studied. No foundry sand involving malpractice of sand treatment such as overloading with clay or carbonaceous materials was studied.

The data in Tables 1 and 2 are limited to a maximum temperature of 122 F. This temperature was found a practical barrier to the techniques employed. This is because of the rapid loss of water from the sand above 125 F. Moisture evaporation begins below 125 F, but the effect becomes pronounced above this temperature.

Erratic results reflecting moisture loss during testing were obtained at higher temperatures. This is regarded as an important and useful observation. In foundry use, molding sands over 120-125 F can be expected to lose water rapidly. Therefore, they will be erratic in their molding behavior.

When stored in a sealed container at temperatures over 120-125 F moisture moves from the sand mass as a whole and condenses on the container walls. The application of this observation to hot sand in storage bins is evident. Moisture leaving the sand condenses on patterns and causes sticking and other condensation problems. This can be observed in sand testing where condensation and sticking of sand to the specimen support occurs.

For these reasons, the sand should be cooled during mulling to a temperature below 120 F. If the sand is discharged, from the muller at higher temperature, for example 160 F, moisture can be expected to leave the sand rapidly. This results in moisture segregation in storage, channeling in bins, condensation on patterns, and erratic green- and dry-strength sand properties.

EFFECTS OF MULLING HOT SAND

In studying the properties of molding sands at temperatures over 120-125 F, it became obvious that the mulling and cooling of the sand was a major factor of the problem of hot molding sands. It was found impractical to try to achieve constant temperature during the mulling cycle by mulling at temperatures from 125 F and over. This is especially true at temperatures over 160 F.

At the higher temperatures, a constant percentage of moisture can not be retained in the sand during mixing. Rapid evolution of water vapor is encouraged by the mulling action. Both the temperature and moisture content of the sand decrease in a short time interval during mulling as shown in Fig. 1. Once the sand temperature has decreased to 120 F or below during mulling, both moisture content and sand temperature fall slowly.

Figure 1 applies specifically to the sand charge and mulling conditions employed, but illustrates the general principles. In this specific case, a 4500 gram batch of dried molding sand was charged in the muller at 250 F. The full amount of water was added and mulling begun at once. No exhaust system was attached to the muller. Evaporation took place to the open air by the mixing action of the muller.

Prior to mixing the batch, several batches of sand at the same temperature were mixed to bring the muller wheels and other parts up to the operating temperature. This mulling technique is the same as that in foundries with a hot sand problem. In these foundries sand is charged into the muller at a higher temperature, and mulled to a lower temperature by moisture evaporation. Figure 1 is an example of the changes in temperature and moisture of the sand during mulling.

While these changes in moisture and temperature of the sand are occurring, the properties of the sand also begin to develop from the mulling action (Fig. 2). To obtain data for Fig. 2, a 4500 gram batch of sand was charged into the muller at 270 F and 6.0 per cent water was immediately added. The same mulling conditions were employed as for Fig. 1.

Mulling was continued for 3.0 min and samples were withdrawn for tests at appropriate intervals during mulling. The test results yielded data which are plotted in Fig. 2.

The curves for temperature and moisture content of the sand show the same trend as in Fig. 1. Figure 2 also shows that green compressive strength is developed early, and continues to rise throughout the mulling period. However, dry compressive strength rises to a maximum and then begins to decrease again. Increasing dry strength early in the mulling period is the result of water distribution, wetting of the sand, and the mechanical effects of mulling. Decreasing dry strength later in the mulling period is the result of drying out of the sand. It can be seen that the mulling of hot sand involves two important physical processes–1) during mulling cooling of the sand occurs with its resultant evaporation of moisture, and 2) later in mulling, the properties of the sand are developed. These two processes will be considered separately.

COOLING OF HOT MOLDING SANDS

When hot molding sands are mulled, temperature and moisture content of the sand decrease according to the general principles discussed and illustrated in Fig. 1. This decreasing temperature and moisture content of the sand is bound to occur.This is because of the physical laws of vapor pressure and heat of vaporization of water over the temperature range up to 212 F shown in Fig. 3.

This figure shows that vapor pressure increases rapidly once temperatures over 125 F are reached. Furthermore, the large surface area over which the water can be spread in a sand greatly accelerates the rate of evaporation. This combination results in an unstable moisture level in the sand during mixing at temperatures over 125 F—especially over 160 F. The temperature of sand in the muller must then drop as moisture evaporates until a fairly stable moisture content and sand temperature is reached. The level at which the decreasing moisture and sand temperature curves in Fig. 1 become stable will vary. The level will vary with the type of muller and its speed (rpm), exhaust system, size and temperature of sand batch, and timing and amount of additions.

Even the per cent of water added at the beginning of the muller cycle influences the rate at which the sand is cooled to a temperature of 120 F or lower (Fig. 4) Two different batches were mulled using the techniques described. The sand was charged into the muller at 350 F. In one case, 6.67 per cent water was added, and in another 4.67 per cent water was added at the beginning of the cycle. With more water present initially, Fig. 4 shows that a temperature of 120 F was reached in 3.60 min of mulling. When less water was present initially 4.9 min were required.

MOISTURE IN SAND

The moisture retained in the sand is higher when the water added initially is higher. In all cases studied, the sand temperature could be mulled down to 120 F rapidly by adding all the water immediately at the beginning of the mulling cycle.

Water added to the muller should be regarded as having two different purposes - 1) water for cooling the sand, and 2) water to be mulled into the sand and retained as temper water. The amount of water required for cooling can be theoretically calculated.

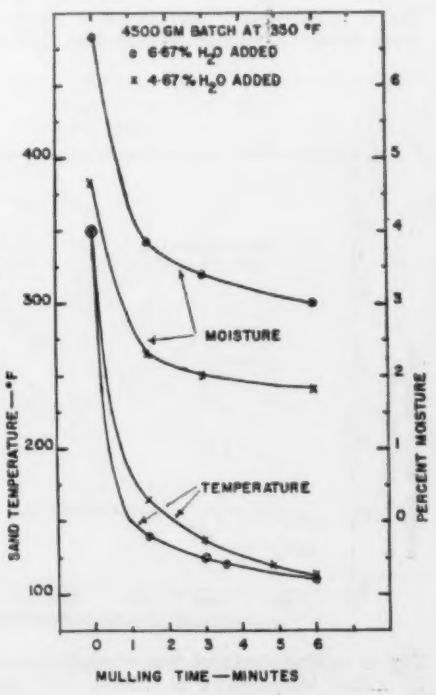

Fig. 4 – Effect of mulling time on moisture content and temperature of two batches of hot sand charged into muller at 350 F with initial moisture additions of 4.67 and 6.67% respectively.

TABLE 3 — WATER NEEDED IN MULLER

Conditions

Initial sand temperature = 350 F
Specific heat* of sand = 0.183 Btu/lb/F
Cooling water = 68F
Final sand temperature = 120F

Solution**

1. Heat given up by sand in cooling to 120F: 0.183 x (350—120) = 42.2 Btu/ lb.
2. Heat taken on by water on heating from 68 F to 120 F and evaporating at 120 F
   1.0 x (120—68) = 52.0 Btu
   1025.0 Btu (from fig. 2, Btu to evaporate water at 120 F)
   1077.0 Btu/lb water
3. Pounds of water required to cool one lb of sand from 350 F to 120 F. 42.2 Btu/lb sand—1077.0 Btu/lb water = 0.0392 lb water or approximately 3.90 per cent water are required to cool the sand from 350 F to 120 F assuming none condenses and drips back into the muller.

*Average of experimentally determined values for several molding sands over the range.
**This method is an approximate one of sufficient accuracy for the purpose of this paper.

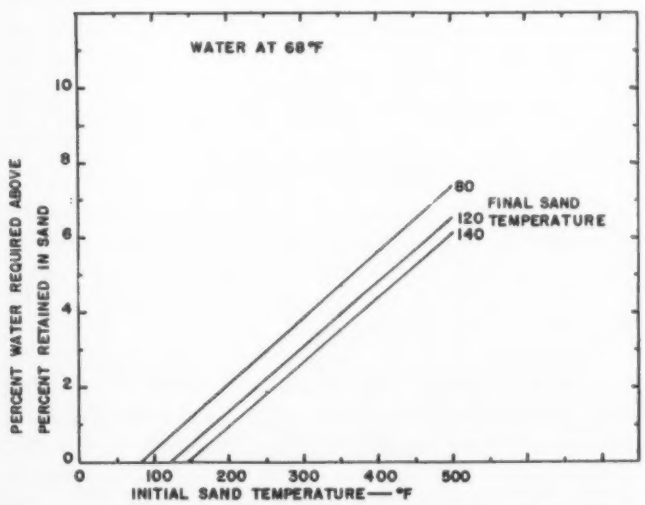

Fig. 5 — Theoretical percentage of water required to cool sand from its initial temperature to 140, 120, and 80 F.

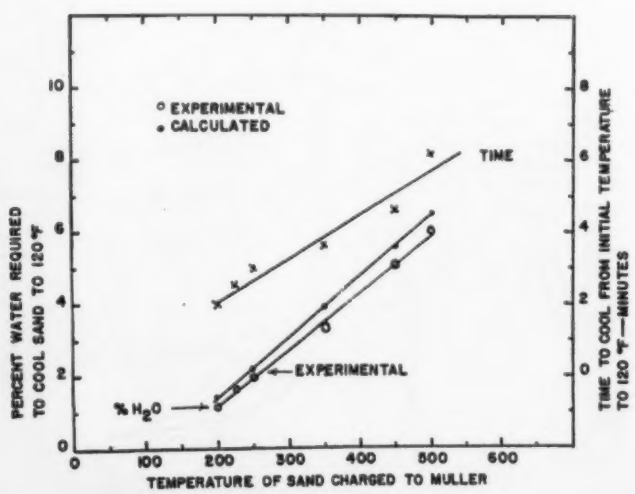
EXPERIMENTAL
CALCULATED
TIME
EXPERIMENTAL
% H2O
PERCENT WATER REQUIRED TO COOL SAND TO 120 °F
TIME TO COOL FROM INITIAL TEMPERATURE TO 120 °F — MINUTES
TEMPERATURE OF SAND CHARGED TO MULLER

Fig. 6 — Experimental water requirements to cool sand from its initial temperature to 120 F and cooling time required.

Consider the problem in Table 3.

In Table 3 the total water added to the muller must allow 3.90 per cent for cooling and evaporation, plus the percentage to be retained as temper water.

The theoretical water requirement was calculated in this way from several initial sand temperatures. This requirement is plotted in Fig. 5 for final temperatures of 80, 120, and 140 F. The theoretical calculations can be checked against experimental determinations from the data and graphical presentations in Figs. 1 and 4. For a 4500 gram batch of sand charged into this muller at 250 F with 4.80 per cent moisture, Fig. 1 shows that the water content has decreased to 2.80 per cent and the temperature to 120 F. after 3.0 min mulling.

This indicates an experimental evaporation loss of 2.0 per cent for cooling the sand from 250 F to 120 F. compared with a calculated loss of 2.20 per cent. Experiments at other initial sand temperatures gave the results listed in Table 4. The experimental and calculated evaporation losses in Table 4 are plotted in Fig. 6. Figure 6 shows the experimental losses are about 10 per cent less than the calculated ones. This is probably due to condensation of the steam and its return to the sand by drippage from the muller parts.

Time is required to cool the sand since the water must be evaporated. For example, Fig. 1 shows that 3.0 min are required to mull the sand from 250 F to 120 F under the conditions described. The time required to cool the sand down to 120 F is listed in Table 4, and plotted in Fig. 6 for various initial sand temperatures.

When insufficient cooling water is added at the beginning of the mulling cycle, the time required to cool the sand is extended. Except for the case at 350 F when insufficient water was added initially, the data in Table 4 and Fig. 6 assume that sufficient water has been added to cool the sand and leave water for tempering at 2.8 to 3.9 per cent.

Even with sufficient water present, time is required for the sand temperature to decrease to a temperature where mulling begins. Not until the sand grains are cooled to about 160 - 170 F will moisture remain on them long enough so that effective mulling begins. When the average temperature is above 160 to 170F, evaporation occurs so rapidly during mixing that a true mulling action does not occur.

Rapid cooling of hot sands can be accomplished by a maximum water addition at the beginning of the cycle. The magnitude of the addition is based on the total of that required for cooling, plus that percentage to be retained as temper water. For the mulling conditions studied in this report this is the percentage shown in Fig. 6 for the initial temperature of the sand, plus the temper water desired.

For other mixing conditions, the percentages will be somewhat different from those shown in Fig. 6. This depends on the nature of the mixing equipment and process. Finally, a mulling cycle of constant time interval does not guarantee equivalent mixing of successive batches of hot sand of varying temperature. This is because of the time required to cool the sand to a temperature where mixing begins.

The value of a constant time for a complete mulling cycle for hot sands may be questioned on the basis

of the foregoing observations. Since the temperature of the ingoing sand may vary frequently, the time required to mull to any specific lower temperature will vary. A better practice is to control the time of mulling during a specific temperature interval, such as 160 F to 120 F, at some minimum time.

An alternative is—time measurement of the mulling portion of the cycle might not be started until the sand was cooled to 160 F. The initial time required to cool the sand to 160 F could be allowed to vary depending on the ingoing temperature of the sand, mulling conditions, etc. A definite time period for effective mulling would be guaranteed. This works in the laboratory.

DEVELOPING PROPERTIES OF HOT MOLDING SANDS

The moisture content and temperature of hold molding sands is transient during mulling. This is until a sufficient mulling time has elapsed so a stable moisture content and temperature combination is reached. It follows that the green and dry properties of the sand will develop to reflect the change in temperature and moisture content of the hot sand as it is mulled.

For comparison, the development of sand properties during room temperature mulling must be known. Consider the mulling of new sand mixture of 8.0 per cent western bentonite, and 92 per cent 85 AFS sand with 4.0 per cent water. The effect of mulling time in a sealed 18 in. diameter vertical wheel muller operating at 42 rpm on green compressive strength and dry compressive strength is shown in Fig. 7.

These properties rise to a maximum and then remain virtually constant as mulling time increases. Figure 7 also indicates that green strength is developed more rapidly than dry strength during mulling. This can be emphasized by replotting the data in Fig. 7 as in Fig. 8. The latter figure is a graph showing how green strength and dry strength vary simultaneously during the mulling period. The curves in Fig. 8 show that green compressive strength increases a little with increased mulling time. Dry compressive strength increases greatly. Adequate green strength can be reached quickly by mulling, but it may take longer to develop adequate dry strength.

This is a significant point regarding hot molding sands. A major effect of high sand temperatures is to decrease the effective mulling time. High sand temperatures can delay dry strength development. Referring to Fig. 8, a standard curve of the combinations of maximum green and dry compressive strength developed in this sand at different moisture contents by mulling at room temperature is shown. In mulling a new mixture the properties must gradually approach maximum as the graph shows. Mulling is complete.

TABLE 4 – EFFECT OF SAND TEMPERATURE ON COOLING DURING MULLING

Initial Sand Temp. F	Total Water Added %	Water Retained in Sand at 120 F %	Water Evaporated Initial Temp. to 120 F %	Calculated % Required To Cool Sand to 120 F	Mulling Time to Cool Sand to 120 F, Min
250	4.80	2.80	2.00	2.20	3.0
350	4.67	1.90	2.77	3.90	5.0
350	6.67	3.30	3.37	3.90	3.6
450	8.45	3.40	5.05	5.60	4.1
500	9.05	3.00	6.05	6.50	6.20
225	5.60	3.90	1.70	1.80	2.50
200	4.38	3.20	1.18	1.35	2.00

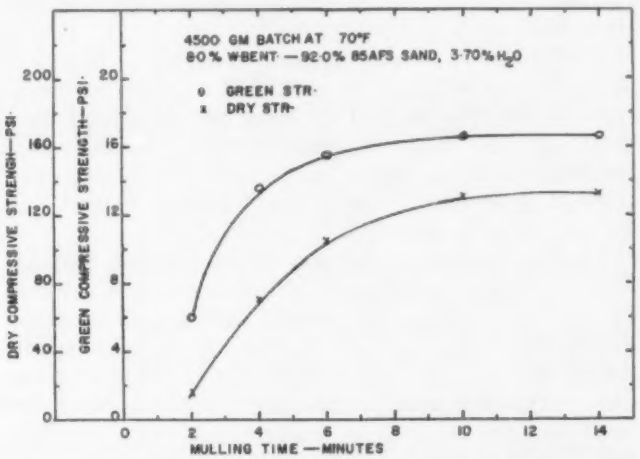

Fig. 7 – Effect of mulling time on green strength and dry strength developed of a new sand mixture at room temperature, 70 F.

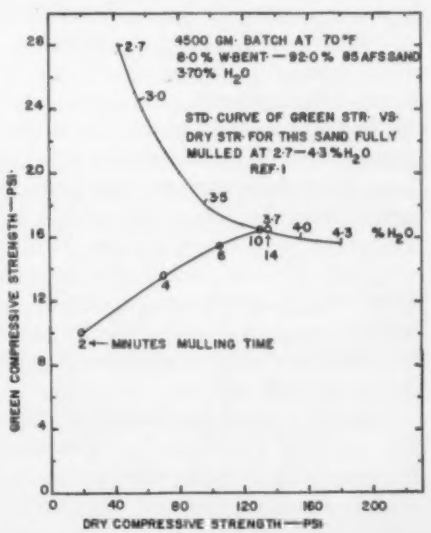
4500 GM. BATCH AT 70°F
8.0% W-BENT — 92.0% 85 AFS SAND
3.70% H2O
STD. CURVE OF GREEN STR. VS. DRY STR. FOR THIS SAND FULLY MULLED AT 2.7—4.3 %H2O
REF. 1
%H2O
MINUTES MULLING TIME
GREEN COMPRESSIVE STRENGTH—PSI
DRY COMPRESSIVE STRENGTH—PSI

Fig. 8 – Approach with increasing mulling time of the green strength-dry strength combination for new western bentonite sand mixture to the standard values of a fully mulled sand.

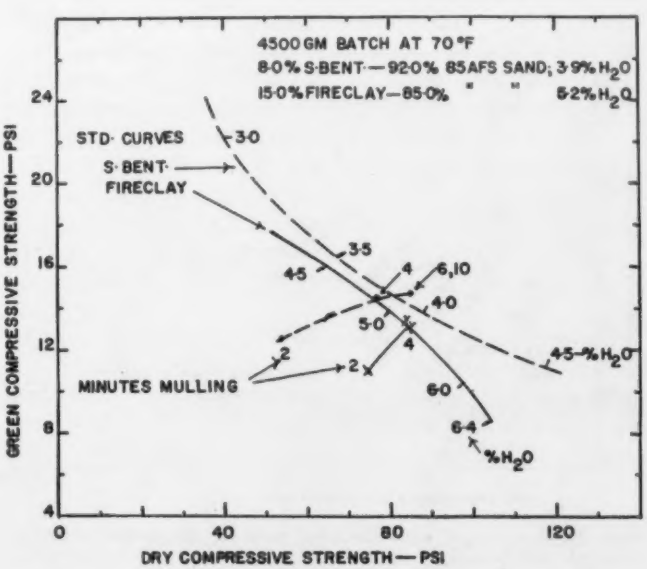

Fig. 9 – Same as Fig. 8, fireclay and southern bentonite mixes.

Curves similar to Fig. 8 can be obtained for other bonding clays such as southern bentonite and fire clay as shown in Fig. 9. This figure indicates that southern bentonite mulls to maximum properties more rapidly than western bentonite. It also shows that fire clay is unique in that its maximum dry strength is reached at about the same time as maximum green strength.

It cannot be overemphasized that Fig. 7, 8, and 9 apply to new sand mixtures mulled at room temperature. If the fully mulled mixtures are dried and then remulled, the same changes takes place, but total mulling time to reach maximum green and dry strength is reduced from 6 to 10 min to 2 to 3 min for each clay-bonded type.

The first mulling cycle takes longer, possibly because it requires time for dispersion and attrition of the clay as well as wetting with water. The second cycle requires only wetting with water. In foundry sands, where the sand has been mulled a number of times part of the clay may be thoroughly mulled. New clay additions for rebonding require the longer mulling times for developing maximum properties.

The foregoing data shows that adequate green strength can be developed more quickly than adequate dry strength by mulling at room temperature.

When hot molding sands are mulled, the progress of developing green and dry strength depends on sand temperature. If the sand is so hot that moisture will not remain on the sand grains, molding sand properties will not begin to develop during mulling.

As sand temperature decreases during mulling, a temperature is eventually reached where the moisture will wet the sand grains (and clay), and remain long enough for mulling to progress. By visual observation of hot sands charged into the muller at temperatures of 120 to 500 F, permanent wetting of the sand grains and effective mulling appears to be about 160 to 170 F.

When the sand has cooled to this temperature, further mulling develops the green and dry properties in a manner similar to that at room temperature.

This sequence of events has been illustrated in Fig. 2 for a 4500 gram batch of sand charged into 18 in. D

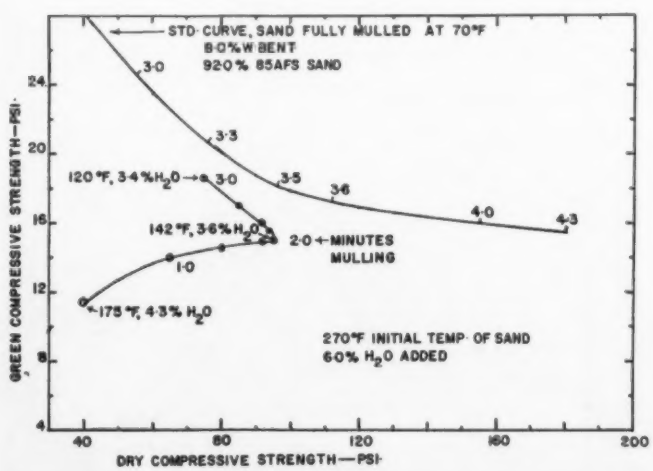

Fig. 10 — Change with mulling time of green strength-dry strength combinations of a hot sand toward the room temperature green strength-dry strength combinations. The lower curve on this graph is replotted from Fig. 2.

verticle wheel muller at 270 F and 6.0 per cent water. The sand mixture was composed of 8.0 per cent western bentonite, 92 per cent 85 AFS 4-screen sand pre-mulled at room temperature for 10 min.

Green strength is developed early and continues to rise throughout the mulling period (Fig. 2). Dry strength rises to a maximum and begins to decrease. The increasing dry strength of the early portion of the mulling period curve is the result of wetting and water distribution. Decreasing dry strength later in the mulling period is due to drying out of the sand. With continued mixing and decreasing temperature, the dry strength (and related green strength) of the hot-mulled sand should approach that of the same sand mulled at ambient temperatures.

This is shown by the data of Fig. 2 as in Fig. 10. The standard combinations of green and dry compressive strength for this sand thoroughly mulled at room temperature over a wide range of moisture contents is shown on the solid line curve in Fig. 10. The combinations of green and dry strength of the hot mulled sand of Fig. 2 are also shown, as is mulling time and moisture content of the hot sand.

At first green strength develops quickly and increases slowly, while dry strength increases rapidly toward the maximum possible during the mulling and cooling of the sand. When the sand temperature has dropped to about 140 F, continued mulling is accompanied by a decreasing dry strength and rising green strength because of moisture evaporation. Further changes in green and dry strength with increased mulling time parallel the changes occuring at room temperature. This is largely controlled by moisture content.

The combination of green strength and dry strength of the hot mulled sand usually does not reach the maximum combination developed by mulling the same sand at room temperature. Early in the cycle Fig. 10 shows that the green strength is low by only a small amount, while the dry strength is low by a large amount. After mulling the sand for 60 sec to a moisture content of 4.10 per cent, Fig. 10 shows that green strength is only 1.3 psi low, 15.8 max compared with 14.5 psi. Dry strength under these conditions, however, is 100 psi low, 165 max compared with 65 psi actual.

These principles imply that when molding sands are mulled hot, little loss of green strength is to be expected. Dry strength is likely to be low unless mulling is continued long enough. Erratic dry strength behavior is the result of the observation as applied to foundry sand usage. If the foundry has a fixed mulling cycle, but considerable variation of the temperature of sand charged into the muller, the result will be erratic dry strength behavior. This has been observed in foundry sand practice.

Figure 11 shows the erratic dry strength properties developed after mulling 1.50 and 4.0 min under the mulling conditions previously described for a western bentonite bonded sand. Figure 12 shows similar results for a southern bentonite bonded sand. In both cases, the general trend of increased sand temperature is to increase the range of dry strength values noted at a particular moisture content. More variation is encountered at higher sand temperatures and the shorter mulling time.

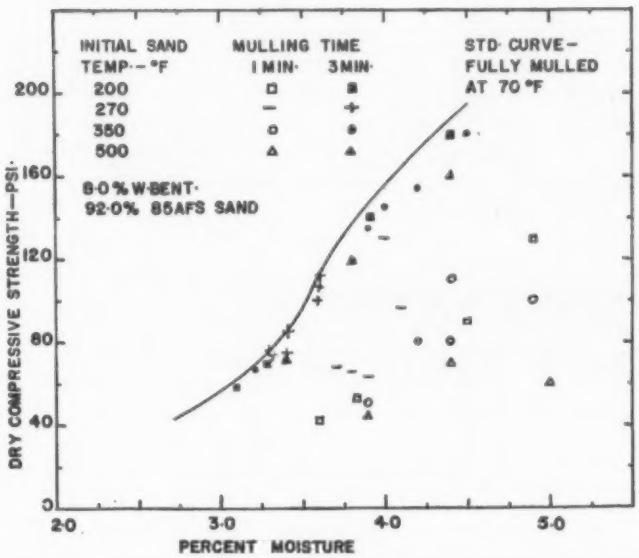

Fig. 11 — Approach of dry compressive strength of hot mulled western bentonite sand toward maximum obtained by mulling at room temperature as time increases from 1 min-3.0 min.

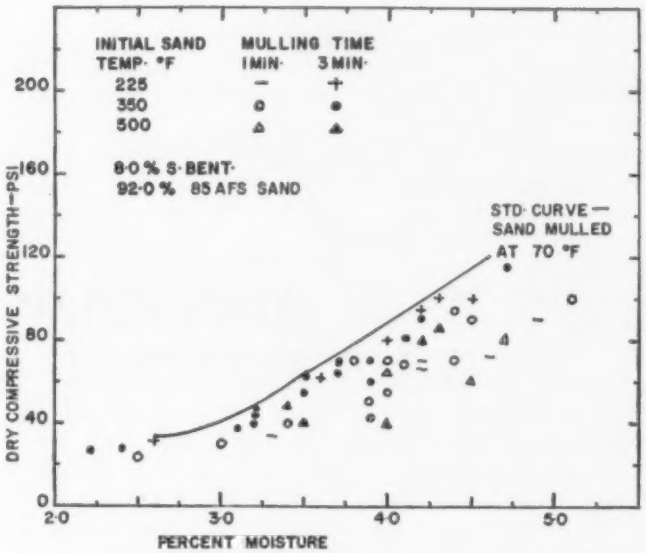

Fig. 12 — Same as Fig. 11 for southern bentonite sands.

In both cases (Fig. 11 and 12), the green compressive strength of the hot mulled sand was either identical with or only slightly lower than the anticipated value. Also, dry strength may be a little low or much lower than the anticipated value, depending on the initial temperature of the sand, total mulling time, and the final temperature to which the sand was mulled. The essential point is that if the sand is mulled long enough to cool it to a temperature below 120F, a combination of green and dry strength will be developed. This will be reasonably close to the combination obtained by mulling the same mixture at room temperature.

If a few tenths of a per cent additional water is added during the last 30 sec of the muller cycle after it has cooled below 130 F, the final combination of green and dry strength will be almost identical with those obtained by mulling at room temperature.

The combinations of green and dry compressive strengths obtained by mulling at room temperature have been extensively investigated and reported.[1] This information provides the basis for room-temperature properties toward which the properties of hot molding sands will develop during mulling. The extent to which hot sands approach the properties developed at room temperature depends on the technique employed in mulling.

If the sand is mulled long enough to cool it to 120 F or below, and a tenth or a few tenths of a per cent moisture are added late in the cycle, the properties of the hot sand will be close to or identical to those developed by room temperature mulling. The foregoing assumes that the sand has not been heated to a high enough temperature to cause decrepitation of the clay bond present.

1. R. W. Heine, E. H. King, J. S. Schumacher; "Correlation of Green strength, Dry Strength, and Mold Hardness of Molding Sands" 1958 AFS TRANSACTIONS, MODERN CASTINGS, March 1958, p. 49.

SUMMARY

The hot sand problem of production foundries involves two important physical processes.

First, the sand must be cooled to a temperature where effective mulling begins. The cooling process requires a definite time interval and per cent water addition depending on the temperature of the ingoing sand. Batch size, cooling air, type of muller, rpm of mulling, ambient temperature, and other variables also influence the actual cooling time required in any particular foundry set up.

Nevertheless, there will be a certain minimum time required for cooling the sand to a temperature when effective mulling begins (160-170 F in these investigations). The total mulling cycle involves time for cooling, plus time for effective mulling at temperatures of 160 F or under.

Second, mulling must be continued after the initial cooling period. This will cause adequate dry strength to be developed, and permit the sand to approach the ideal dry and green strength combinations which result from room temperature mulling. The criterion of adequate mulling time for hot sand should be dry compressive strength (or combination of green and dry strength) rather than green strength.

The actual details of desirable mulling techniques for cooling hot sands and developing properties will vary depending on the condition existing in foundries having a hot sand problem. Techniques which have proven satisfactory in the cases studied are suggested in this paper.

Other problems such as condensation on patterns, and sticking of sand grains to the condensate are particular to temperature differences between the sand and patterns. These difficulties will decrease as the sand is effectively cooled and mulled to below 120 F.

STEEL SCRAP SPECIFICATIONS FOR DUPLEXING CUPOLA WHITE IRON

By

R. H. Greenlee*

INTRODUCTION

Many foundries leave to their purchasing department the full responsibility of selecting and purchasing the proper grades of steel melting scrap for their melting operations. This is often done without proper specifications being first submitted to the Purchasing Department by Metallurgy or the melting personnel. In this case, purchasing must shoulder the full responsibility of obtaining steel scrap without the benefit of a specification requirement.

As can be seen under these circumstances, Purchasing is often unaware of the increased melting costs which results from the purchase of improper scrap. Through this error, there has undoubtedly been a tremendous quantity of poorly prepared, alloy contaminated steel scrap used by various foundries. This type of scrap although it may have been purchased at a reasonable cost is costly when considering its effect on melting losses and producing quality iron.

PURPOSE

It is the purpose of this paper to:

1. Present known facts which result from the use of improper steel melting scrap. Particularly facts which affect costs and metal quality.
2. To describe a program which was instituted at the author's company to give concrete proof for the necessity of requiring rigid specifications for the purchase of steel melting scrap for cupola—electric-duplexing of malleable iron.
3. To list those specifications which were necessary to insure quality iron at reduced costs, and to describe our steel melting scrap program as it is in effect today.
4. Tabulate benefits resulting from the above program.

EFFECTS OF UNDESIRABLE MELTING SCRAP

Clips, busheling, etc. when exposed to the air blast of a cupola are an undesirable charging material. They have a high ratio of surface to weight, and melting losses can be expected to rise accordingly. This loss is due primarily to excessive oxidation on the exposed metal surfaces. Chemical analysis at the spout is difficult to maintain within a certain chemical range.

Silicon and manganese losses are higher. Charging this material is difficult, particularly if automatic charging equipment is used.

The average car of steel scrap contains varying quantities of rusty, heavily-scaled scrap. This type of material is undesirable, because melting and oxidation losses are increased. Also, the metallurgical properties of the iron produced from this type of scrap are impared. Using heavily oxidized material in the charge make-up requires a higher silicon and manganese base for a given analysis of these elements at the spout.

Additional limestone is necessary to flux these oxides, as more erosion of the lining is experienced. This creates additional cost for repairing. It is difficult to control the analysis of an iron when the charge consists of a considerable per cent of this material. Wide fluxations are experienced in the chemical analysis of the iron at the spout. This makes it almost impossible to adjust the charge properly.

Alloy found in otherwise good melting stock has created many problems for the metallurgist. This is particularly true when chromium is present. Small quantities of chromium in white iron retard the time required to graphitize white iron to malleable iron.

Foundries carrying 0.03-0.04 per cent residual chromium in their iron have added several hr to their annealing or malleablizing cycle. Many castings throughout the malleable industry have been scrapped because of high chromium content.

White iron containing 0.09-0.15 per cent chromium will not anneal completely regardless of the length of the annealing cycle. Other elements such as nickel, copper, and aluminum, have their deleterious effects on the degree of graphitization of white iron. Each of these elements promote the formation of primary graphite during solidification.

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Approximately three years ago a program was instituted at the author's company to study the effect and relationship of the various types of steel plate and structural melting scrap to cupola melting losses. An acceptable method of calculating cupola melting losses was the first consideration. After studying this problem it was decided that two methods of approach would be desirable. One from the standpoint of dollar value, and the other from weight loss.

If the following factors were recorded, cupola melting losses could be calculated within a fair degree of accuracy, and would show fluctuations in melting losses due to changes in charge make up providing the large tonnage figures considered were:

1. Accurate weight of all raw materials being charged into the cupola.
2. Actual costs of these raw materials.
3. Weight of metal poured.

The weights of all raw materials in the cupola were recorded on recording tape connected to the charge scales. These weights were totaled each day. To calculate the per ton cost of raw material charged, current delivered prices were used.

The weight of poured metal represented the total weight of the iron in the molds for that particular day. All spill, drops, etc. were remelted in the electric furnace to eliminate these variables in computing melting loss.

The electric furnace was being used only as a holding furnace for the refining and superheating of cupola metal. Therefore, any losses sustained here would be small and for the purpose of our tests remain quite constant. Figures shown as per cent melting loss include any loss resulting from the operation of the electric furnace.

Following is a report on the first of a series of three tests which indicates a relationship between melting loss and scrap preparation.

Melting Loss Due to Scrap Preparation

This report shows amount of dollars lost through melting when light, poorly-prepared steel scrap is purchased and used for melting stock. The following factors were carefully analyzed for 27 consecutive days:

1. Raw material cost per ton charged each day.
2. Melting loss recorded each day.
3. Quality and type of steel scrap.

For calculating the cost of the raw materials required to charge one ton of iron, all raw materials with the exception of foundry returns were considered. They include pig iron, steel, coke, limestone, flourspar, soda ash, manganese briquettes, silvery piglets and ferro-boron.

The steel melting scrap was divided into four types:

1. Extra light steel scrap
   Steel approximately 1/32-in. thick
2. Light steel scrap
   Steel between 1/32-in. to 3/16-in. thick
3. Medium steel scrap
   Steel approximately 1/4-in. thick
4. Heavy steel scrap
   Steel 1/4-in. and up—including structural, and hydraulic steel bundles.

Table 1 shows raw material cost per ton according to the type of steel scrap used. Each dollar value represents the average cost per ton of purchased raw materials for each ton charged based on one day's operation.

According to Table 2 had we been able to charge heavy melting scrap in place of the extra light to medium scrap for the 16 days we used lighter scrap, we would have saved $5,992.40. Also, during this same period, we would have saved 103.3 tons of iron lost due to oxidation in the cupola. This is over and above that which would have been lost had we been able to charge heavy melting scrap.

Further tests were made involving an additional 6000 tons of melting scrap. The results of these tests were essentially the same as noted in Table 1 and Table 2.

To conclude this series of tests 4320 tons of metal were melted in the cupola using approximately 25-30 per cent hydraulic steel bundles. The average cost of the raw materials per ton melted was $26.36. This figure is again a comparative one and does not represent current prices.

The same cost per ton of all raw materials was maintained throughout all tests. This figure of $26.36 represents the lowest cost figure based on 50 per cent foundry returns obtained in any of the tests run.

The type of scrap most frequently melted in the cupola prior to these tests falls under the classification of fairly light steel plate. This type of melting scrap gave a cost of $27.29 per ton melt. A savings of $0.93 per ton resulted when using hydraulic bundles instead of this scrap.

Normally, hydraulic steel bundles can be purchased at a cheaper price per ton so the actual savings becomes even greater. It is the conclusion of the author's company that well prepared alloy-free hydraulic steel bundles are the most economical source of steel scrap for cupola melting of white iron.

TABLE 1 — RAW MATERIAL COST PER TON

Extra Light Scrap	Light Scrap	Medium Scrap	Heavy Scrap
$27.11	$25.51	$25.51	$24.55
27.19	25.61	25.96	25.07
27.46	25.71	25.39	24.42
27.59	25.51	....	24.83
26.61	26.26	....	25.02
....	25.81	....	24.33
....	25.86	....	24.95
....	26.35	....	24.53
....	....	....	24.78
....	....	....	24.86
....	....	....	24.53
Ave. 27.19	25.83	25.62	24.71

TABLE 2 — COST VS. LOSS

	Extra Light Scrap	Lgt. Scrap	Med. Scrap	Heavy Scrap
Ave. cost/ton/melt	$27.19	$25.83	$25.62	$24.71
Dollars lost/ton Heavy scrap/std.	$ 2.48	$ 1.12	$ 0.92	$00.00
Total dollars lost heavy scrap/std.	$2896.64	$2405.76	$690.00	$00.00
Tons melted	1168	2148	750	2990
Tons lost	79	116.7	27	91
Per cent melting loss	6.8	5.5	3.6	3.04
Tons lost per type scrap heavy scrap/std.	43.3	52.8	4.2	00.00

The extent of the savings will depend upon the preparation of the bundles, the source of the clips, and the amount used. The larger the per cent bundles used, the greater the savings as compared to the use of light plate for cupola charge makeup.

Specifications for Steel Melting Scrap

At the conclusion of the foregoing tests it was evident that rigid specifications for purchased steel melting scrap would be necessary if melting costs were to be kept under control. From the results of operating tests, the hydraulic steel bundle was selected to represent the bulk of our steel melting scrap.

One of the disadvantages of using steel bundles is that of detecting tramp elements which may be contained within the bundles. These tramp elements are not visible from the outside of the bundles. To solve this problem it was necessary to specify the sources of clips being used to produce the bundles.

Sources of clips, after plant inspection, were accepted or rejected on the following basis:

1. Chemical analysis.
2. Size and shape.
3. Possibility of alloy being mixed with them.
4. Physical appearance—clean, rusty, etc.

Dealers producing bundles for the author's company were permitted to use only those sources of clips which were on an acceptance list. Other clips found in bundles from unknown sources were used as a basis for car rejection.

All incoming cars of steel scrap are checked carefully for alloy contamination, quality of bundles, cleanliness of the car, etc. This information was recorded and became a permanent record for each dealer.

Cars of bundles entering the foundry are previously checked by qualified laboratory personnel. They report the condition of the cars in respect to size and quality of the steel bundles, and whether there is alloy in the cars. This report, and further checking if necessary, is carefully considered.

As a result, the car is either accepted or rejected. If rejected, the dealer who produced the bundles is notified that specifications have not been adhered to and the car has been rejected for use in the foundry. Cars which meet specifications are further checked during unloading or during charging. Accepted cars which, during unloading, are found to not meet specifications are rejected and the dealer notified.

Through a constant routine checking of scrap it has been possible to improve the quality of steel melting scrap.

BENEFITS REALIZED

Benefits realized from a program such as described have been extensive. One of the most important is that of uniformity of melting conditions. This resulted in a closer control of chemical analysis. Steel bundles being quite uniform in size allowed for deeper blast penetration of the coke bed, less tendency for slag freezing at the tuyeres, and lower cupola back pressures.

It is interesting to note that with less cupola back pressures we were able to obtain 500-700 cu ft per min more air thru the centrifugal blower than previously.

Silicon and manganese losses have been reduced by the use of cleaner scrap resulting in lower metal cost at the cupola spout. Annealing cycles have been held to a minimum due to the absence of alloy contamination in the iron. Generally, annealing cycles for the malleablizing of white iron accommodate the fluctuation of chemical analysis of the white iron. The greater the fluctuations, the longer the annealing cycles.

Proper control of melting scrap and close control of all melting operations results in a more uniform analysis. Residual alloys contained in the iron will be held to a minimum. The net result will be shorter annealing cycles, lower anealing costs, and increased annealing capacity.

It is not uncommon for foundries to occasionally find they have castings which do not anneal properly. Upon investigation they find residual chromium content in the iron to be high. Occasionally, the chromium content is found to be of such a high per cent that it is necessary to actually scrap the castings. This has been avoided by close control of all incoming scrap to be used in the melting operation.

Records show that cupola melting losses have been reduced over the past three-year period. Higher manganese and silicon recovery have been experienced thus producing iron at a lower spout cost.

CONCLUSIONS

1. Melting costs can be reduced in any foundry by instituting quality specifications on all incoming melting scrap.
2. Less casting scrap will be produced due to chemical analysis, particularly from high residual alloys contained in the iron alloys which originated from purchased scrap.
3. Annealing costs will be reduced as a result of shorter annealing cycles.

THE CHEMICAL TREATMENT OF COPPER ALLOYS

By

R. W. Ruddle*

INTRODUCTION

The chemical treatment of molten metals is far from being a new branch of applied science. Records are available which show that chemical treatments were practiced as early or earlier than 1500 B.C. There are numerous accounts of chemical treatments carried out during the last few hundred years. For example, a 17th century bell founder stated that he was able to improve the soundness of his castings by adding copper scale and potash to the metal prior to pouring. Hull[1] states that during the last century founders commonly added an empty whiskey bottle to brass melts with the object of reducing zinc loss.

Until recently the approach to this subject was entirely empirical and little was known of the mechanism underlying the treatments practiced. However, in the last few decades a more scientific approach has been made to the subject and this has led to considerable progress in the understanding of the reactions which take place during the melting and casting of metals.

The purpose of this paper is to review some of the standard chemical methods of treating molten nonferrous alloys and to give some indication of the underlying theory behind these treatments.

The main purposes of chemical treatment are:

1) Reduction in melting losses.
2) Prevention of dross formation which leads to inclusions in the casting.
3) Removal of gases.
4) Production of the correct grain structure in the casting.

MELTING FLUXES

The extent to which metal is lost during melting as a result of oxidation varies considerably with the type of furnace used. Reverberatory and other furnaces where a large area of surface is exposed give the largest loss and electric furnaces the smallest. Some actual figures are highly instructive. For example, with gunmetals, Hanson and Pell-Walpole[2] quote losses in reverberatory furnaces of 0.7-4 per cent. In crucible melting the recent work of Jackson and Brown[3] has indicated gross losses of about 2-4 per cent in melting leaded gunmetal. Cook[4] has shown that during yellow brass melting with induction furnaces the loss is normally about 2 per cent. Conversion of these figures into dollars and cents show that the financial loss is considerable. Frequently, the melting loss accounts for more than half the cost of melting.

The precise alloy being melted also has a large effect on the loss. For example, in crucible furnace melting Jackson and Brown[3] found losses of 2 per cent with 85-5-5-5 red brass, 4 per cent with 86-7-5-2 leaded gunmetal, negligible losses with phosphor bronze, about 3 per cent with yellow brass and about 2.5 per cent with high tensile brass. The figures quoted are those obtained when good practice is employed. Where practice is less than good, the melting loss may rise as high as 10 per cent or more.

A commonly used method of reducing the metal loss is to spread a layer of charcoal about 1-2 in. thick on the surface of the melt. This acts mainly as a chemical barrier to the diffusion of oxygen into the melt and may also to some extent provide a physical barrier against the outward diffusion of zinc vapor. Jackson and Brown[3] have shown that with certain alloys, in particular, those which do not have a high zinc content, (i.e. a zinc content not exceeding about 5 per cent), a charcoal cover produces a substantial reduction in melting losses. For example, with red brass the melting loss is reduced from 2 per cent to about 1/2 per cent by a cover of this type.

However, charcoal covers are much less effective in alloys where certain elements, such as zinc, are lost preferentially by volatilization. Here the fluid flux cover is the best means of lowering melting losses. The whiskey bottle already mentioned is an early cover of this type. Use of such covers can give, under production conditions, melting losses as low as 0.1-0.2 per cent. Jackson and Brown,[3] for example, found that with high tensile brass the melting loss was lowered from 2.5 per cent to about 0.1 per cent by such a cover, as illustrated in Fig. 1. Similarly Pursall[8] found that fluid flux covers reduced the metal loss in melting 65-35 yellow brass from 3.6 per cent to 1-2 per cent depending on the precise flux used.

*Technical Manager, Foundry Services, Inc., Columbus, O.

Fluxes of this kind are usually based on materials such as glass and borax. They are of such composition that they do not increase the normal attack on crucibles or furnace linings and are not so viscous that metallic particles are trapped in the flux when it is skimmed from the melt prior to pouring. Their main action is physical and they present a substantial barrier to the diffusion of gases in or out of the melt. It may be noted that the diffusion of metal and oxygen is extremely slow in silicate or borate slags.

Sometimes these protective fluxes include ingredients added for the removal of impurities from the melt. Aluminum, iron, zinc, phosphorus, arsenic, lead and silicon are among the impurities which can be removed in this way. Figures 2 and 3 show how the removal of iron and zinc respectively are effected by the oxidizing power of the flux.

With alloys containing elements which have a high affinity for oxygen but which form tenacious oxide skins, (aluminum in aluminum bronze is an example), melting losses are generally low, about 0.25 per cent.

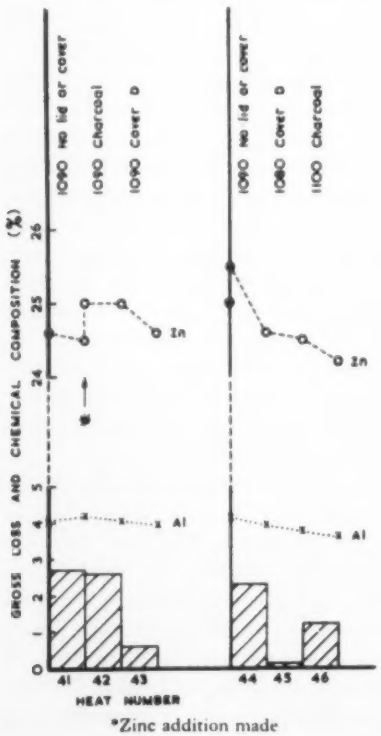


Fig. 1—Effect of various melting treatments on metal loss in crucible furnace, high tensile brass.[3]

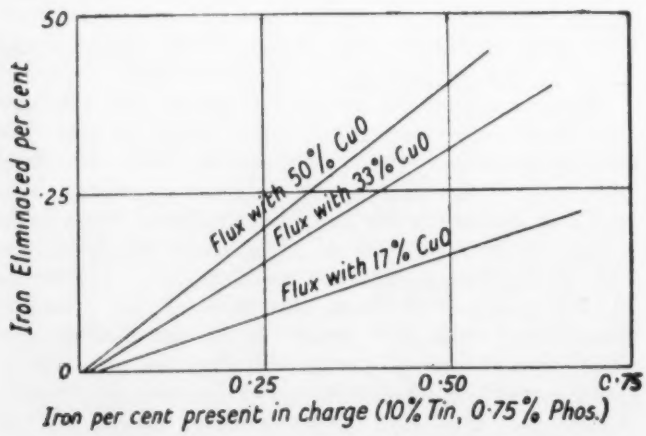


Fig. 2—Effect of flux composition on iron removal from phosphor-bronze.[8]

A film of alumina is formed on the surface. This reduces the loss of other elements by oxidation and volatilization, acting in this respect much like a glass cover. However, formation of these films presents serious difficulties in aluminum bronze and similar alloys since the films make the metal sluggish and difficult to run. Furthermore, the oxide films may give rise to inclusions on the surface and in the interior of the casting. Besides being unsightly they have a marked weakening effect on the mechanical properties. Fluoride-containing fluxes which absorb alumina are now widely adopted in practice for stripping oxide films from the metal surface thus greatly reducing these difficulties.

Recent work by Sully, Hardy and Heal[5] with light alloys has shown that although these fluoride fluxes dissolve a little alumina, their main action in removing alumina films from the surface of the melt is a physical one. The fluxes wet the oxide films and cause them to float into the flux layer. For those interested in this subject, computations made by Atterton[6] indicate that the surface tension of the flux must exceed about 1 dyne per cm for effective removal of alumina films. Atterton states that this condition is comparatively critical and that only certain quite restricted ranges of flux composition have surface tensions in excess of this value and are thus able to remove alumina films.

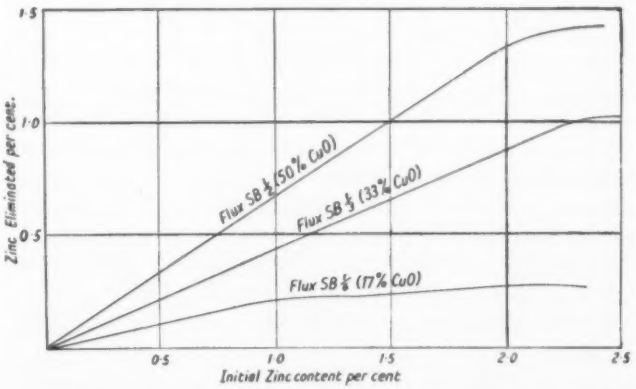


Fig. 3—Effect of flux composition on zinc removal from phosphor-bronze.[8]

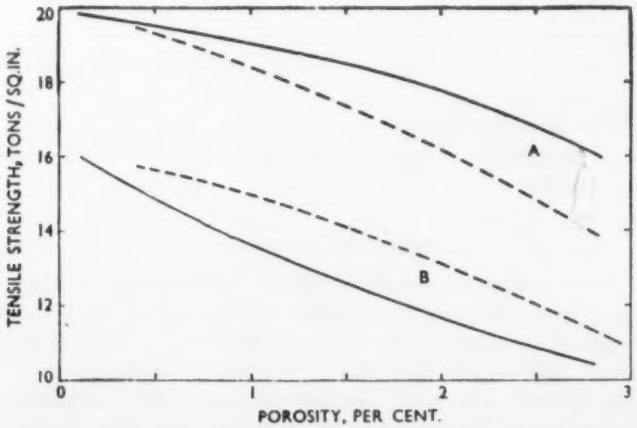


Fig. 4—Effect of gas porosity on strength of (A) lead-free 88-10-2 and 88-8-4 gunmetals and (B) leaded 85-5-5-5 red brass. Both deoxidized with phosphorus.
- - - Porosity due to gas dissolved in melt.
—— Porosity caused by mold reaction.

GAS REMOVAL

The principal gases which dissolve in metals in substantial quantity and therefore cause trouble during solidification of the casting by giving rise to porosity are hydrogen and several compound gases, such as steam, carbon monoxide and sulfur dioxide.

The extent to which hydrogen or other gas porosity is harmful to the properties of copper alloy castings is shown in Fig. 4. This illustrates the effect of gas porosity on the tensile strength of 88-10-2 and 85-5-5-5 gunmetals. Other types of copper alloys, e.g., aluminum bronze, are similarly affected although gas porosity is relatively seldom troublesome in the casting of the yellow brasses.

For simplicity, treatments designed to remove hydrogen and to prevent compound gas formation are considered separately below.

Hydrogen Removal

The solubility of hydrogen in liquid copper or other liquid metals is relatively high but falls abruptly when the metal or alloy freezes, thereafter continuing to fall slowly as the temperature decreases (Fig. 5). Hence, if a casting has a gas content exceeding the solid solubility at the melting point, the excess gas will be suddenly thrown out of solution when metal freezes and bubbles will form in the casting. In a very slowly cooled casting in which freezing was fully directional most of these bubbles could probably escape. But in practice this situation rarely obtains and usually most of the bubbles are trapped within the solidifying casting causing gas porosity.

If a gassy melt is allowed to stand in air, much of the hydrogen dissolved in the majority of copper alloys will diffuse through the surface of the melt into the atmosphere. However, because of the diffusion barrier offered by the presence of the oxide skin on the surface the process is too slow to be of practical consequence. It can be made faster simply by stirring the metal with a paddle, thus breaking up the oxide skin and bringing gassy metal to the surface. Much greater acceleration can be produced by stirring under a flux cover which absorbs the oxide present on the surface and thereby removes one of the barriers to outward diffusion.

Still more rapid hydrogen removal may be obtained by purging the melt with an inert gas which is insoluble in the metal. The dissolved gas diffuses into the bubbles of inert gas as they rise to the surface of the melt. To make this process as rapid as possible it is desirable to insure that the bubbles are as small as possible and are released as near as possible to the bottom of the melt. A given volume of gas passed through the melt will be more effective if the bubble size is small than if it is large since in the former case the surface area of the bubbles is a maximum.

It should be pointed out that the effectiveness of degassing, although high at first, falls off as the gas content of the melt is reduced. It follows that if it is desired to reduce the hydrogen content of the melt to a very low value, large volumes of purging gas are necessary. However, the gas content of the melt can be lowered to commercially satisfactory values such that porosity troubles are not serious in a relatively short time.

The scavenging gas used to remove hydrogen from copper alloys is nitrogen. Baker and Child[7] studied the degasification of copper alloys in considerable detail, finding that 100 lb melts could be effectively degassed by passing dry nitrogen at 5 to 10 litres per minute (0.177 to 0.353 cu ft per min) for about 5 minutes. The practice of nitrogen degassing however presents some difficulties owing to the necessity of using relatively fragile refractory tubes to introduce the gas into the melt (stout graphite tubes are best). Also it is a nuisance to transport nitrogen cylinders and the attached tubing, etc., about the melting area. For these reasons nitrogen degassing has never become popular in copper alloys foundries.

Prevention of Compound Gas Unsoundness

(a) Mechanism of Porosity Formation

As already mentioned, compound gases are also a common cause of porosity in copper, bronzes and gunmetals, and nickel alloys. The three gases involved are steam, sulfur dioxide and carbon monoxide. Only the steam reaction is considered here in detail since the mechanism of porosity formation by sulfur dioxide and carbon monoxide is similar; and steam reaction porosity, from the point of view of most foundrymen, is probably the most important of the three.

Both hydrogen and oxygen dissolve quite freely in copper and many of its alloys. The concentrations of these elements in the melt tend to reach equilibrium with the moisture content of the furnace atmosphere according to the following equation:

$$H_2O\,(g) = \underline{2H} + \underline{O}\ ^{*}$$

During freezing the solubility of both gases falls as seen earlier when hydrogen alone was considered. As the result, steam bubbles form within the melt, and unless remedial measures are taken severe gas porosity will frequently result. The relationship between the oxygen and hydrogen contents of the melt

*The symbols $\underline{H}$ and $\underline{O}$ indicate that these elements are dissolved in the metal.

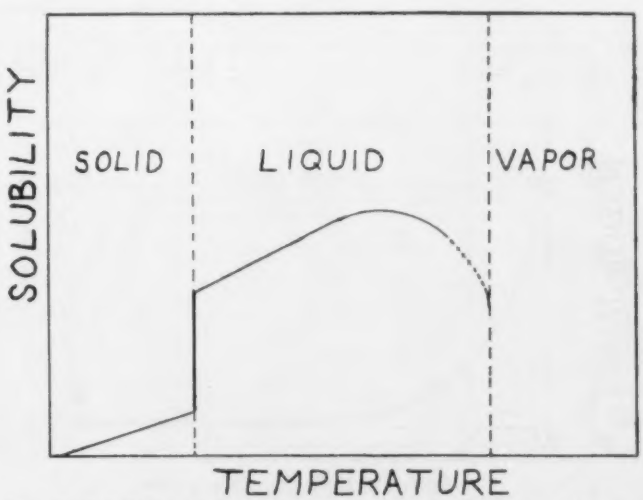
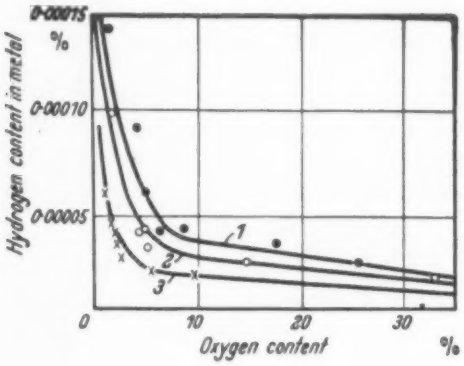


Fig. 5—Solubility of hydrogen in copper alloys as a function of temperature (diagrammatic).



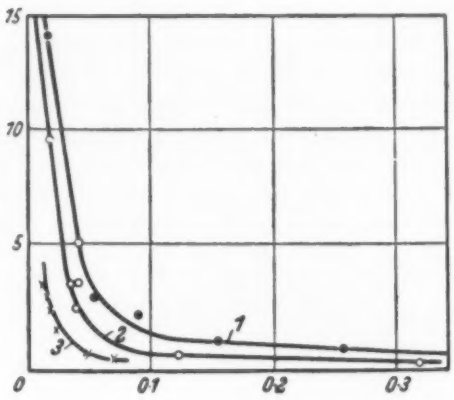


Fig. 6—Equilibrium between hydrogen and oxygen dissolved in molten copper. (A) left—the effect of temperature (1 = 2642 F; 2 = 2282 F; 3 = 2102 F); (B) right—the effect of water vapor pressure (1 = 335 mm Hg; 2 = 234 mm Hg; 3 = 92.5 mm Hg).

are governed by the equilibrium constant of the above reaction as given in the following equation:

$$K = \frac{[H]^2\,[O]}{pH_2O}$$

Where [H] and [O] are the concentrations of hydrogen and oxygen respectively in the metal and pH_2O is the pressure of water vapor in the furnace atmosphere.

This means that at any one temperature, assuming a given pressure of water vapor in the furnace atmosphere, the (limiting) concentration of oxygen in the melt is inversely proportional to the square of the concentration of hydrogen. Conversely the (limiting) concentration of hydrogen is proportional to the square root of the concentration of oxygen. In other words, as the concentration of one gas increases, that of the other is reduced. The concentrations of these two gases in a copper or copper alloy melt are therefore related by curves of the kind shown in Fig. 6. The precise position of the curve depends on the temperature of the melt and on the moisture vapor pressure. Increase in either of these quantities shifts the curve upwards as illustrated in Fig. 6.

It should be emphasized that the gas concentrations given by the lines in Fig. 6 are the maxima that the melt can hold under the conditions assumed. It is possible for the melt to contain less gas than indicated by these curves. It follows that the actual plotted gas contents can fall to the left of the curve under consideration but not to the right of it.

(b) Oxidation-Reduction Treatments for Prevention of Unsoundness

It is obvious from Fig. 6 that if the oxygen content of the melt is raised to a relatively high value, the hydrogen content is limited to a low value. This fact is the basis of the oxidation-reduction degassing treatments so frequently employed in practice. The way in which this kind of treatment works can be illustrated by reference to Fig. 7 and 8. Let it be assumed that a particular melt has picked up moderate quantities of both hydrogen and oxygen during melting and that the concentration of both of these elements are given by Point 1 on Fig. 7.

The melt is now oxidized in order to expel the bulk of the hydrogen. Some oxidation can be effected by insuring that the metal is melted under an oxidizing flame. But to secure thorough hydrogen removal it is also normally necessary to treat the melt with an oxidizing flux. This treatment increases the oxygen content of the metal to that corresponding to Point 2 on Fig. 7. Hydrogen is thereby expelled from the melt as water vapor. The concentrations of oxygen and hydrogen travel down the curve of Fig. 7 from Point 1 to Point 2.

It is necessary to remove the bulk of the oxygen introduced by the oxidizing treatment immediately prior to pouring the melt. A deoxidant such as phosphorus must, therefore, be added to the melt. This reduces the oxygen content of the melt to a low value corresponding to Point 3 on Fig. 7. The hy-

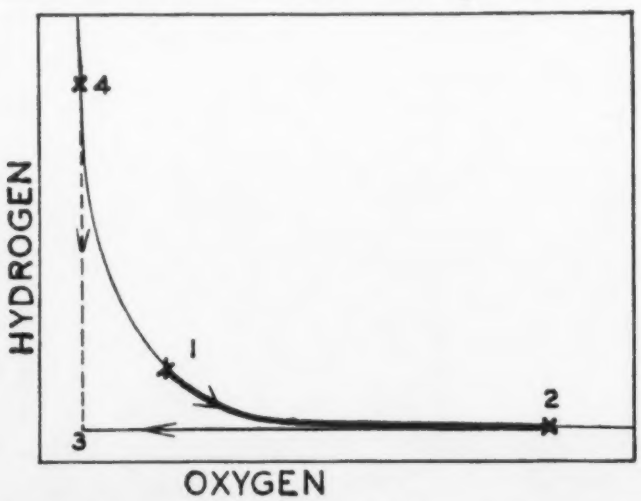


Fig. 7—Degassing by oxidation-reduction and by gaseous flushing (diagrammatic).

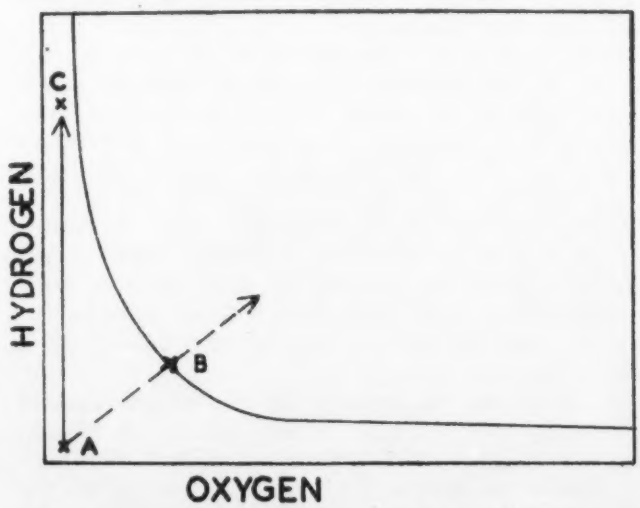


Fig. 8—Diagram illustrating concentration of hydrogen and oxygen in residual liquid during freezing.

drogen content remaining is substantially unaffected. The oxygen is removed (when phosphorus is used as the deoxidant) according to the following equation:

$$2P + 4Cu + 7O = 2Cu_2O.\ P_2O_5\ (slag)$$

The deoxidation product is a cuprous phosphate slag of the approximate composition $2Cu_2O.\ P_2O_5$ and it may be noted that one unit by weight of phosphorus removes about 1.8 units by weight of oxygen.[9,10]

It might be thought that addition of sufficient phosphorus to bring the oxygen content of the melt back to Point 3 on Fig. 7 would suffice and that castings then made from the melt would be sound. This, however, is not so for reasons which can best be explained by reference to Fig. 8. This figure, which is qualitatively similar to Fig. 7, illustrates the equilibrium between hydrogen and oxygen in solidifying metal. It corresponds to a lower temperature and to a water vapor pressure of about 1 atmosphere (760 mm or 29.9 in. of mercury) instead of to a water vapor pressure of a few tenths of an in. of mercury as is the case with Fig. 7 which applies to conditions during melting. Assume that the oxygen and hydrogen concentration represented by Point 3 of Fig. 7 correspond to Point A on Fig. 8.

It will be noted that Point A is well removed from the curve. It must be remembered that steam bubbles cannot be formed in the melt unless the concentrations of oxygen and hydrogen when plotted yield a point on or to the right of the curve. Then the steam pressure at least equals the atmospheric pressure. However, during freezing of the casting both oxygen and hydrogen tend to concentrate in the still liquid part of the casting. The solid metal frozen in the earlier stages of solidification contains very little of either of these elements. The oxygen and hydrogen concentrations in the liquid metal, therefore, tend to move along a line such as A B. Eventually these concentrations reach the critical value for steam evolution, at, for example, Point B. This generally happens fairly late during the freezing process. The steam bubbles formed at this stage are unable to escape from the casting and therefore give rise to gas porosity.

For this reason it is necessary to add extra deoxidant to the melt when carrying out the deoxidizing treatment discussed above. This additional deoxidant does not much affect the location of Point 3 since at this point the small concentrations of oxygen and phosphorus dissolved in the melt are in equilibrium with each other. However, as soon as the oxygen concentration tends to rise during the freezing process the reaction above goes to the right and the "extra" oxygen is precipitated in harmless form as small globules of cuprous phosphate slag.

This, of course, does not affect the way in which hydrogen concentrates in the residual liquid during freezing but it does prevent the oxygen from similarly concentrating. The hydrogen-oxygen concentrations in the residual liquid, therefore, travel along line A C instead of along line A B of Fig. 8. It will be observed that these concentrations must move a long way along line A C before the concentrations of the two gases reach the critical value and for this reason gas porosity does not develop unless the hydrogen concentration of the melt was initially high.

It is instructive to consider the amounts of phosphorus necessary to prevent steam reaction unsoundness from arising. The initial deoxidation effected before pouring (along the Line 2-3 in Fig. 7) generally necessitates a phosphorus addition of about 0.01 per cent. Recent studies of the equilibrium between oxygen and phosphorus in copper melts have shown that in order to prevent undue concentration of the oxygen during freezing a residual phosphorus of about 0.005 per cent is necessary[11]. This is illustrated by Fig. 9, which shows the porosity found in

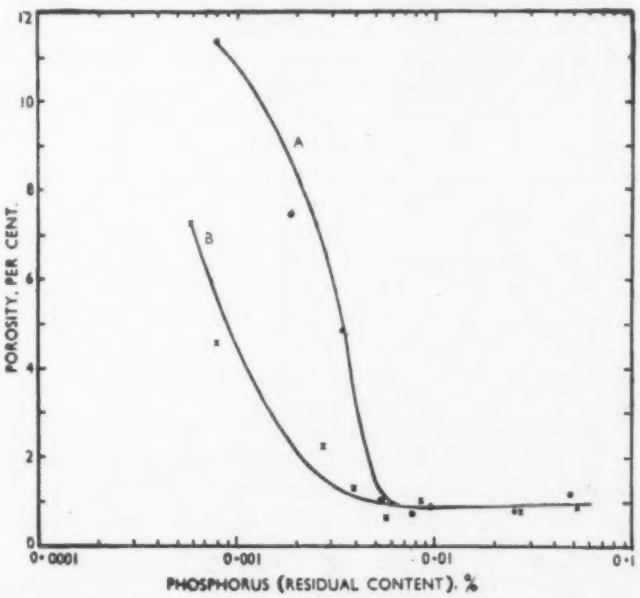


Fig. 9—Effect of residual phosphorus content on porosity of 6-1/4-in. chill-cast ingots in cadmium-copper. (A) Metal of moderate hydrogen content. (B) Metal purged with nitrogen.

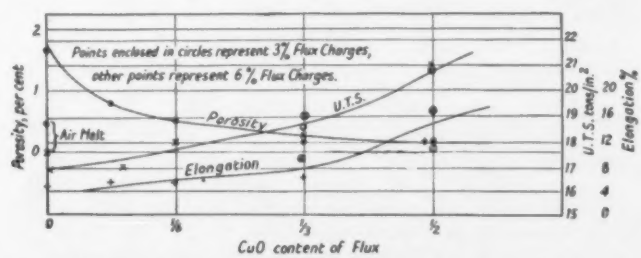


Fig. 10—Effect of oxidizing power of flux on soundness and tensile properties of 88-10-2 gunmetal (chill-cast stick).

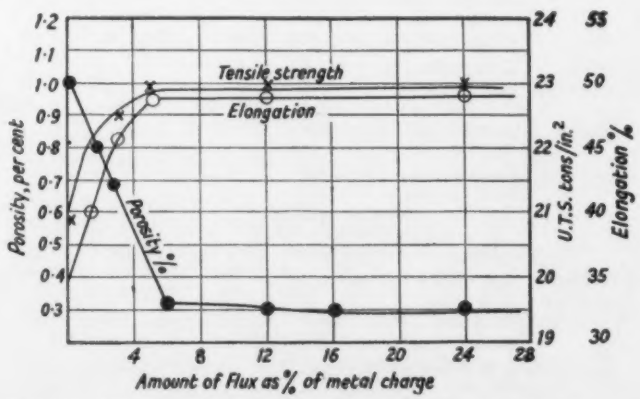


Fig. 11—Effect of amount of flux used on soundness and tensile properties of the bronze (chill-cast stick).

ingots of copper-cadmium alloy with low oxygen content and low or moderate hydrogen contents at the time of deoxidation. It follows that when using the oxidation-reduction treatment the minimum effective phosphorus addition is about 0.015 per cent. In practice a somewhat larger addition, 0.02-0.025 per cent, is usually made to allow a safety factor.

(c) Gaseous Degassing Treatments

Another method of insuring freedom from gas unsoundness is to melt the metal under a charcoal or other reducing cover. This prevents the melt from picking up oxygen and also largely deoxidizes the melt should the charge itself contain oxygen. Hydrogen is, however, freely admitted to the melt during melting under charcoal and when the melt is ready for pouring, the gas concentrations are liable to be as depicted by Point 4 on Fig. 7.

The hydrogen can be readily removed by passing nitrogen or other inert gas through the melt as discussed earlier. At the end of this process the concentrations of hydrogen and oxygen are again given by Point 3 of Fig. 7. Deoxidation is again imperative to prevent concentration of both oxygen and hydrogen in the melt. But since the oxygen content is already much lower than is the case when the oxidation-reduction treatment is effected, a smaller phosphorus addition of, say 0.01 per cent, is adequate.

(d) Practical Fluxes and Deoxidizers

Reducing fluxes employed when nitrogen purging is adopted generally contain a fair amount of carbonaceous material. On the other hand oxidizing fluxes consist of an oxidizing agent, such as cupric oxide and a fusible salt which gives the flux adequate fluidity. For example, Baker and Child[7] recommend a flux consisting of cupric oxide and potassium nitrate. Hanson and Pell-Walpole[2] suggest the use of either cupric oxide or manganese dioxide as the oxidizing agent. Sand or glass is often used as the fluidizing material. Naturally the effectiveness of a flux depends to some extent upon both its oxidizing power and on the quantity of flux used. The influence of both these variables is illustrated in Figs. 10 and 11. These figures, which apply to metal used in the manufacture of chill-stick, show that while the effectiveness of the flux increases progressively with its oxidizing power there is a useful limit to the proportion of flux used with a given melt.

It might be thought that the main effect of the oxidizing flux would be to reduce the amounts of easily oxidizable elements in the alloy, such as tin, zinc and phosphorus, before effecting any substantial hydrogen removal. However, in fact, hydrogen elimination is successful and the loss of these metals is relatively small. The reason for this is probably that the reaction between hydrogen and cupric oxide takes place mainly at the flux-metal interface. The rate of diffusion of hydrogen to this interface is rapid whereas that of the metallic elements, tin, etc., is relatively slow.

Furthermore, the fact that steam can readily escape from the slag means that equilibrium between the oxygen content of the slag and that of the metal is not attained until a large part of the hydrogen has been removed from the melt. The slag, on the other hand, soon becomes saturated with the oxides of tin, etc., and a condition of local equilibrium between the slag and the adjacent region of the melt is soon reached. When this occurs, further oxidation of these elements is slow owing to the slow diffusion already mentioned.

The main requirements of deoxidizers are: (a) a high affinity for oxygen, (b) that the products of the deoxidizing reaction should separate readily from the melt, preferably as a fluid slag, and (c) that excess of the deoxidizing element remaining in the metal should not adversely affect it. Among the substances used for deoxidation are calcium, calcium boride, calcium silicide, copper, magnesium, lithium, phosphorus, manganese boride, silicon and sodium.

Of all these phosphorus is far and away the most valuable since it is cheap and forms a liquid deoxidation product. The efficiency of deoxidation by phosphor copper is to some extent dependent on the grading and phosphorus content of the material. It has been shown that relatively large lumps are preferable to fine powders. It has also been established that it is best to add the phosphor copper in one unit rather than in small quantities[6]. Calcium boride also forms a liquid deoxidation product but this material is relatively expensive. Its main use is its application to high conductivity copper where an excess of phosphorus in the melt has an adverse effect on the electrical conductivity.

Residual phosphorus also has an undesirable effect on nickel alloys. With these alloys deoxidizers such as manganese, magnesium, lithium and boron are generally used. Sometimes it is economic to use phos-

TABLE 1 – EFFECT OF VARIOUS DEGASSING TREATMENTS ON THE DENSITY AND MECHANICAL PROPERTIES OF SAND-CAST COPPER ALLOYS

Alloy	Treatment	Density, g/cc	Tensile Strength, lb/in²	Elongation in 2 in., %
88-10-2 Gunmetal	Phosphorus dexoidized only	8.60	32,950	21
	Melt treated with oxidizing flux Phosphorus deoxidized	8.71	41,450	36
	Melt gassed with hydrogen Phosphorus deoxidized	8.57	31,800	13
	Melt gassed with hydrogen; later treated with oxidizing flux and phosphorus deoxidized	8.62	41,650	28
	Melt gassed with hydrogen; later degassed with nitrogen and phosphorus deoxidized	8.80	45,250	25
88-8-4 Gunmetal	Melt melted in reducing flame Phosphorus deoxidized	8.46	20,900	6.5
	Melt melted in oxidizing flame Phosphorus deoxidized	8.74	34,950	17
	Melt melted in oxidizing flame, treated with oxidizing flux and phosphorus deoxidized	8.74	45,450	38
85-5-5-5 Red Brass	Melt melted in oxidizing flame Phosphorus deoxidized	. . .	32,250	17
	Melt melted in oxidizing flame; later treated with oxidizing flux and phosphorus deoxidized	. . .	35,250	23

phor copper to effect most of the deoxidation, adding insufficient however, to leave a residual phosphorus content. Final deoxidation is then produced by addition of one of the more expensive but less harmful elements such as lithium. Lithium has the added advantage of also removing hydrogen.

Effect of Degassing Treatments on Tensile Properties

The beneficial effect of degassing treatments on the soundness and tensile properties of copper and copper alloy melts are too well known to require much emphasis but a few examples taken from the literature[7,12] are given in Table 1. See also Fig. 4.

Assessment of Gas Content

It is clearly desirable to know whether a given degassing treatment is in fact proving effective and it is worthwhile considering methods for assessment of gas contents. There are several ways in which this can be done. In research work fusion of a previously solidified sample under vacuum is often resorted to, the gases evolved from the sample being analyzed. This technique is far too slow and expensive for foundry use.

A very reliable method is the measurement of the density of a sand-cast sample of standard shape. From this is computed the porosity of the sample which is a measure of its gas content. This method is most valuable in experimental work and "trouble-shooting" in the foundry. It is perhaps too slow for routine use although a rapid modification which can be completed in 2-3 minutes has recently been developed[13].

An extremely valuable method suitable for routine use is the technique in which a small sample of molten metal is allowed to freeze under vacuum. Gas content of the metal is assessed by observation of the evolution of gas bubbles during freezing or by subsequent sectioning of the frozen slug.

GRAIN REFINEMENT

Until lately there were no generally applicable methods for grain refining copper alloys although it has for a long time been known that refinement can be produced by the addition of relatively large quantities of iron (1 per cent or more). This technique is made use of in many commercial compositions for high tensile brasses and aluminum bronzes. It is not recommended for gunmetals since it is liable to give rise to rust spots and to hard particles.

Dennison and Tull[14] have obtained substantial grain refinement of hypereutectic aluminum bronzes by means of boron additions. It is thought that the boron forms boron carbide particles which serve as nuclei to facilitate the freezing of the aluminum-rich beta phase. This technique has a beneficial effect on mechanical properties. For example, increases of about 13 per cent in tensile strength and 46 per cent in elongation have been obtained using additions of 0.2 per cent boron. More recently the same authors have succeeded in producing some refinement in hypo-eutectic aluminum bronzes by means of additions of molybdenum, niobium, tungsten or vanadium[15].

A few years ago Cibula[16] showed that marked grain refinement could be produced in a wide range of bronzes and gunmetals by addition of 0.03 per cent zirconium together with 0.02 per cent boron, by boron alone or by other elements such as titanium and cobalt. It seems probable that in this instance the nuclei are the carbides and the nitrides of the elements added. However, Cibula found that in many cases grain refinement was not beneficial with copper based alloys, especially bronzes and gunmetals[17]. Although the refinement reduces the total amount of porosity owing to better feeding it unfortunately has the effect of distributing the residual porosity in the form of layers which have a very damaging effect on the mechanical properties and especially on pressure-tightness. On the other hand, when normal unrefined gunmetals are cast at temperatures which are too low a sound and pressure tight skin of columnar crystals is produced.

CONCLUSION

In conclusion it should be emphasized that this review has skated very briefly over the subject of the chemical treatment of copper alloys. In fact, the details and mechanism of each type of treatment are a good deal more involved than have been indicated. It should also be emphasized that the precise treatment to be employed in any given case depends upon several factors including the type of melting unit and the fuel, the alloy being treated, the form of the charge, the type of casting being made and other factors, and that considerable experience and "know-how" are needed if the best treatment is to be selected.

ACKNOWLEDGEMENTS

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SIEVE RATIOS AND PROCESSING FOR STRONG MOLDING SANDS

By

J. Parisi*, O. C. Nutter**, and C. Michalowski**

ABSTRACT

This paper presents a method for quantitatively relating the proportions of screen sizes for formulating molding sands. The method applied to the 4-screen Schumacher sand shows effective use of 91 per cent of the grain sizes present. The method applied to the typical sands given in the AFS Foundry Sand Handbook also gives good correlation. Analyses of other published screen-size distributions are given.

The important progress made by specific adjacent screen formulations of molding sands is a stimulant for the making of similar progress in the sand preparation phase. Attention to little stressed details is required, such as—1) obtaining the most efficient premixing possible before additions of temper water which reduces the flowability and probabilities for uniform distributions, and 2) application of full mixing and mulling energy uniformly to small volume increments of sand, clay and water.

MOLDING SAND SCREEN-SIZE DISTRIBUTIONS

A survey of the literature indicates that from four to seven adjacent screen sizes are desirable for good all around molding sand properties. A typically good sand listed in the AFS FOUNDRY SAND HANDBOOK (Fig. 86), consists of 5 adjacent screen sizes, plus 2 additional half screens—one on each end. Schumacher's[1] 4-screen sand at a GFN of 69 gives excellent characteristics. Heine[9] found the 4-adjacent screen sand at a GFN of 89 responded readily to jolt molding to give a strong, high hardness mold. Silk[8] found that a good casting finish with minimum expansion troubles can be obtained with 7-adjacent screens.

The question relative to quantitative limits for a 4-screen molding sand was presented by Mr. Schumacher[1]. The following evaluation is considered to throw more light on this subject.

Sand-packing calculations are normally done with spherically-shaped grains, providing a base point to apply deviations consistent with the actual shapes involved. A container filled with uniform-size spheres of any diameter, packed in the closest possible manner, has a total void volume of 26.0 per cent. Depending upon the relative orientation of the layers, the major amount of the void volume can be present as continuous straight holes through the mass of grains, no matter how thick.

In this case appropriately-sized rods can be inserted through the thickness without disturbing any of the spheres. There are three such holes surrounding in each sphere at 120° positions (Fig. 4).

Each unit cell is formed by 6 spheres, and is rhombohedral[7]. There are two cell openings, one at each end in separate parallel planes.

Another form of 100 per cent controlled orientation exists where there is no continuity of open-end cells. This type of void or cell is that formed by one sphere resting in a seat formed by 3 spheres. It is called tetrahedral[7]. The relative sizes of the largest spheres that will fit into the rhombo and tetra voids are 0.414 D and 0.224 D. There is 1 of the rhombo and 2 of the tetra for each large sphere.

The above data deals only with one uniform size of sphere and indicates the sensitive nature of a mass composed of spheres. Variation in permeability can be expected as the dynamics of packing affect the relative number of closed and semi-continuous voids. There are six orderly packing arrangements of uniform spheres, ranging from cubic to rhombohedral. This presents the possibility of formation of some of each within a container along with additional voids at discontinuities.

RHOMBOHEDRAL AND RHOMBIC PACKING

Rhombohedral packing is the closest packing possible. It does not usually exist in foundry sands because of the peculiar screen distribution required. One principal sphere size D will accommodate 1 void sphere size 0.414D, and 2 void spheres size 0.225D. The weight relationships are 91.4 per cent, 6.45 per cent, and 2.1 per cent. Using a starting mesh of 50, the void spheres must come from sizes on 140 and 270 screens.

Two empty screens adjacent to the starting size are required to prevent interference with the formation of a rhombohedral packing. It actually can be rated as a one-sieve sand. This type of structure in the absence of water and clay films would have a low deformation potential from the standpoint of grain shifts described later in cubic system.

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TABLE 1—SIZE RELATIONSHIPS OF STRUCTURE, KEY, SUPPORT, AND VOID BALLS FOR THREE-PACKING SYSTEMS

U. S. Mesh Sizes			Cubic System		Rhombic System		Rhombo Hedral		
							All Void Balls		
Mesh No.	Mean Size	Size Range	Keyball 0.732 D	Support Ball* 0.268 D	Keyball 0.414 D	Void Ball 0.151 D	0.414 D	0.225 D	0.17 D
		0.0469	0.03433	0.0126	0.0194	0.00707	0.0194	0.0105	0.008
20	0.0400		0.02928	0.0107	0.0166	0.006	0.0166	0.009	0.0068
		0.0331	0.02423	0.0088	0.0137	0.005	0.0137	0.0074	0.0056
		0.0331	0.02423	0.0088	0.0137	0.005	0.0137	0.0074	0.0056
30	0.02815		0.02061	0.0075	0.0116	0.0042	0.0116	0.0063	0.0048
		0.0232	0.01698	0.0062	0.0096	0.0035	0.0096	0.0052	0.0039
		0.0232	0.01698	0.0062	0.0096	0.0035	0.0096	0.0052	0.0039
40	0.0198		0.0145	0.0053	0.0082	0.003	0.0082	0.0044	0.0033
		0.0165	0.0121	0.0044	0.0068	0.0025	0.0068	0.0037	0.0028
		0.0165	0.0121	0.0044	0.0068	0.0025	0.0068	0.0037	0.0028
50	0.0141		0.01032	0.00378	0.0058	0.0021	0.0058	0.00314	0.0024
		0.0117	0.00857	0.00314	0.00484	0.00177	0.0048	0.00262	0.0020
		0.0117	0.00857	0.00314	0.00484	0.00177	0.0048	0.00262	0.0020
70	0.0100		0.00732	0.00268	0.00414	0.00151	0.0041	0.00224	0.0017
		0.0083	0.00607	0.0022	0.00344	0.00125	0.0034	0.00186	0.0014
		0.0083	0.00607	0.0022	0.00344	0.00125		0.00186	0.0014
100	0.0071		0.0052	0.0019	0.00294	0.00107		0.00159	0.0012
		0.0059	0.0043	0.00158	0.00244	0.0009		0.00132	0.001
		0.0059	0.0043	0.00158	0.00244				
140	0.0050		0.00366	0.00134	0.00207				
		0.0041	0.0030	0.0011	0.0017				
		0.0041	0.0030		0.0017				
200	0.0035		0.00256		0.00145				
		0.0029	0.00212		0.0012				
		0.0029							
270	0.0025								
		0.0017							
		0.0021							
325	0.0019								
		0.0017							

*NOTE: The 0.268 D Cubic Support Ball is for a dead center position. This value increases to 0.276 D for offset positioning. The pocket between cubic keyballs can also be selectively filled with a pair each of 0.261 D, 0.22 D, 0.186 D, 0.167 D, and 0.15 D support balls.

The existence of a rhombic type of structure in a well-graded adjacent screen molding sand is also precluded by considering the screen distributions required for its formation. A starting mesh of 70 with a screen weight of 85.8 per cent requires 14.2 per cent of keyballs having a 0.414 D size. This translates into keyballs having a diameter spread of 0.00344 to 0.00484 (Table 1).

The 140-mesh screen sizes from 0.0041 to 0.059 can supply only half the size range with the largest sizes on the 14 mesh providing interference with close packing. Use of 200 mesh ranging from 0.0029 to 0.0041 supplies only the lower half of the size range of keyballs. This leaves the balance of the 70-mesh balls in a state of looseness, and intermediate types of structure may be formed. Forgetting interference, a 70-mesh rhombic structure requires a screen distribution of 86 per cent on 70, 0 per cent on 100, 7 per cent on 140, and 7 per cent on 200.

CUBIC PACKING

The subsequent evaluations of the four and more adjacent screen sands are done simply on an imperfect cubic basis. Rhombohedral and rhombic packings are improbable in foundry sand distributions.

A structure of greater interest is the body-centered cubic as presented by C. E. Wenninger[6]. The desired sand from the evaluation presented would be a two-screen sand with 71.8 per cent on the first sieve, and 28.2 per cent on the adjacent sieve. This forms a cubical arrangement of large spheres having smaller spheres included in their central void to key or lock their position. Due to practical limitations of obtaining two uniform adjacent screen sizes, a four-screen sand was chosen with the overall probability that 70 per cent of total grains would tend to behave as cube grains and 30 per cent as key grains.

A cubically-arranged sand consisting of 71.8 per cent uniform cube balls and 28.2 per cent key balls is conductive to high compressive strength, low deformation, and high expansion. This is due to continuity of large uniform grains in the three axial directions. A stronger sand will result by the addition of a third grain size such that it would make a dead center contact between the keyballs (Fig. 1) and produce an additional continuous sand network. Under this condition a compressive stress in an axial direction would be supported even if the cube balls were to be removed.

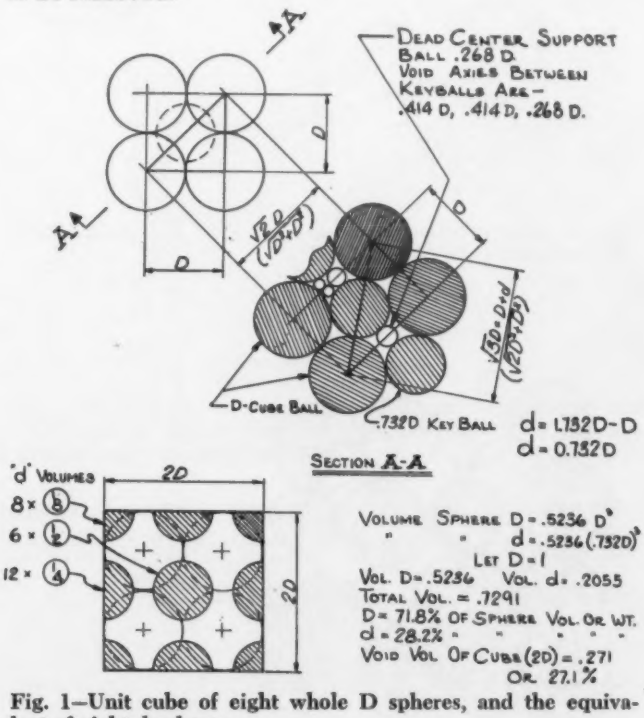

Fig. 1—Unit cube of eight whole D spheres, and the equivalent of eight d spheres.

TABLE 2 — COMPOUND CUBICAL VOLUME RELATIONSHIPS OF VARIOUS MOLDING SANDS

Cube Ball Mesh Size	Schumacher[1] 4 Screen "Fool Proof" Parts Vol.	% Vol.	AFS[2] High Expansion Sand-Fig. 82 Parts Vol.	% Vol.	AFS[2] Controllable High-Expansion Sand-Fig. 83 Parts Vol.	% Vol.	AFS[2] Good Sand-Fig. 86 Parts Vol.	% Vol.	National Malleable and Steel[4] Parts Vol.	% Vol.	General Steel Castings[3] Parts Vol.	% Vol.
20	....	....	1.53	41.2	....	....	....	....	....	....	....	....
30	....	....	1.00	27.0	....	....	1.0	7.5	....	....	1.0	18.7
40	....	....	1.18*	31.9*	1.0	27.5	1.65	12.35	1.0	14.0	1.0	18.7
50	1.0	15.4	....	....	2.64	72.5	3.4	25.5	4.34	62.0	1.52	28.5
70	2.86	44.0	....	....	....	....	5.18	38.9	1.65	23.6	1.82	34.0
100	2.63	40.5	....	....	....	....	2.1	15.7	....	....	....	....

*The 40 Mesh Cubes are short 40% of keyball sizes. Other structures possible.

There are no support balls present. Green strength requires considerable clay.

NOTES: Some of the sands appear to be formulated by the compound cubical relationship. Except as noted in remarks, the major complement of support balls is present. Shortages occur in smallest cube sizes requiring 200 mesh and smaller material.
It is indicated that lowest expansion sands should have less than a 20% volume of starting cube ball mesh size.

TABLE 3 — RELATIVE MESH-CUBE VOLUMES

Mesh No.	Mean Dia.	Cube Edge	Cube Volume X10^{-6}	Volume and Weight Ratios Between Meshes						
20	0.040	0.08	512	1.0						
30	0.0281	0.0563	178	0.347	1.0					
40	0.0198	0.0396	62.1		0.349	1.0				
50	0.0141	0.0282	22.4			0.361	1.0			
70	0.0100	0.020	8.0				0.357	1.0		
100	0.0071	0.0142	2.86					0.357	1.0	
140	0.005	0.010	1.0						0.35	

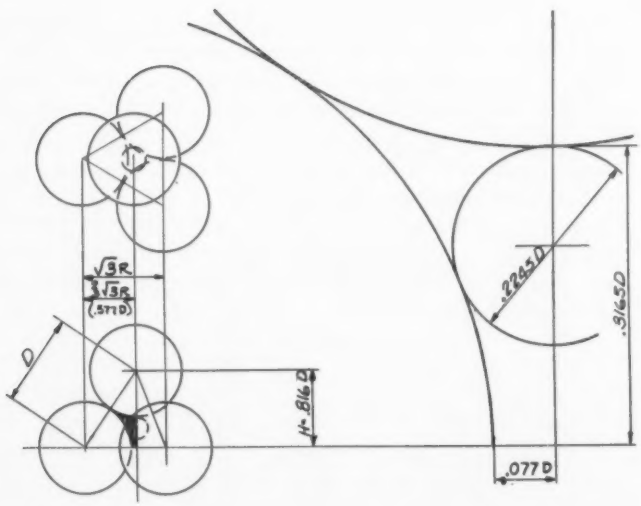

Fig. 2—Determination of tetrahedral void ball in rhombohedral arrangement.

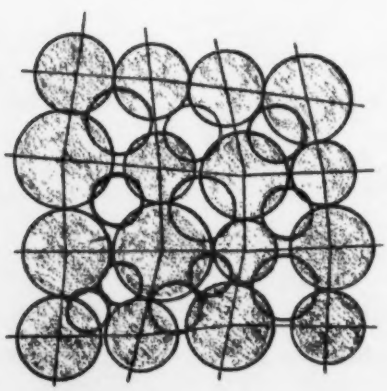

Fig. 3 — Cubical arrangement of nonuniform dia grains.

The cavity between keyballs is not equiaxed. A dead center support ball can roll over into any one of the four corners. In this location, the diameter of the support ball can be increased by 3 per cent. The presence of this larger offset support ball will add to the compressive strength to a lesser degree by the reduced vertical component of the angled compressive force through the support ball.

A horizontally or laterally spreading force component is also produced. However, no spreading or deformation of the sand mass within itself can occur if the cube balls are of uniform diameter. Shifting of cube balls can occur without external volume change if the cubes are imperfectly formed from various diameters (Fig. 3). This is because there are some free to move within their own corner confines. Internal compaction is then possible to counteract heat expansion stresses.

The unequal axes of the pocket between keyballs is a container or confine for a multiplicity of arrangements of smaller sized grains. These can give large or small lateral force components. By an orderly insertion of various sizes, a series of 10 grains may be placed without interference to the proper seating of the next keyball. If a medium-sized grain of the series is introduced first, only seven or less of the series can be placed in the pocket.

This location is one of the places where a small amount of fines can exert a considerable effect on sand properties. This depends upon the state of imperfection of the principal cubic lattice.

FOOL-PROOF SAND

The excellent data presented by J. S. Schumacher[1] is of much interest. The sand cannot be over rammed, and at a high hardness of 92 still accommodates expansions preventing related defects. Assignment of an overall cubic-type structure to sand formulated from adjacent screens has been done in a negative way by elimination of others.

Cubic-type structure is considered to mean an arrangement of 8 cube balls of various sizes where only relatively small inclinations of the faces formed by three of the four balls occurs. The presence of under-size keyballs in a central cavity will permit offsets to occur.

A cubical calculation of the 4-sieve sand reported by Schumacher[1] was done, using the mean-sieve diameters listed in Table 1, and the mesh cube volumes

given in Table 3. Figure 1 shows that a cube formed from 8 mean diameter spheres of a starting mesh will enclose 8 mean diameter spheres from an adjacent smaller mesh. This represents a 1 mesh cube volume of each. The relative volumes of the mean cubes is also the weight relationship. The balance of the material on the first adjacent screen, not required for keyballs of the first, is used as cube-balls in relation to the next screen.

This is repeated, and the excess or unbalanced amounts of sizes can then be found for evaluation. The next calculation is to determine if the proper sizes and amounts of support balls are available to give some degree of continuity to the space between keyballs. Calculation of the Schumacher[1] 4-screen sand is in Table 4.

All of the 50 mesh sand is used as cube balls enclosing 35.7 per cent of its 70 mesh-screen weight. The amount of 70 mesh available for formation of cubes is then 32.81 per cent-3.63 per cent, or 29.18 per cent. This in turn will enclose 0.357 per cent x 29.18 per cent, or 10.42 per cent of the 100 mesh. The balance of the 100 mesh (26.86 per cent) available for cube formation will enclose 9.5 per cent of 140 mesh. This leaves a temporary surplus of 2.3 per cent of the 140 mesh.

To convert the above calculations to a relative volume basis it is only necessary to deal with weights. The weight and volume summary of the 50, 70 and 100 mesh cubes omitting all keyballs since they do not change the volume is in Table 5.

This shows that a good material balance is present for forming a compound or tri-cubic structure sand.

ESTIMATION OF SUPPORT BALLS

Estimation of support balls is done for two conditions. One using a single support ball in the non-equiaxed cavity between keyballs, and the other on the multiple packing of four slightly smaller support balls.

Condition one represents the minimum amount of fines that can give a high-strength structure which will convert with use to and through the second condition as grain fractures occur. The second condition is more representative of original screen sizes present in molding sands. The total relative weights (Table 7) are 1.93 per cent and 5.66 per cent of cube mesh size. The multiple packing will always have both lateral and vertical force components present under a compressive load.

Using single support balls at 0.268D, the 50 mesh cubes require a size range of 0.00314 to 0.0044 (Table 1). Approximately 85 per cent of this size comes from 200 mesh of 0.0029-0041 size. The balance of 15 per cent comes from the smaller end of 14 mesh, size 0.0041-0059.

The total amount required is only 1.9 per cent of the 10.2 per cent of 50 mesh, or 0.19 per cent. This consists of 0.03 per cent of 140 mesh, and 0.16 per cent of 200 mesh.

The 70-mesh cubes require support balls ranging from 0.0022 to 0.00314; 270 mesh. Most of this is supplied by 0.0021-0.0029 with a small amount of 200 mesh required. Total weight needed is 0.56 per

TABLE 4 – SCHUMACHER 60 PER CENT LAKE – 40 PER CENT BANK SAND

Mesh	20	30	40	50	70	100	140	200	270	Pan
Retained	0.08	0.41	1.43	10.20	32.81	37.28	11.80	4.42	0.76	0.83

TABLE 5 – WEIGHTS AND VOLUME

Mesh cubes	% by volume
50	10.2 = 1.00 = 15.4
70	29.18 = 2.86 = 44.0
100	26.86 = 2.63 = 40.5
	6.49

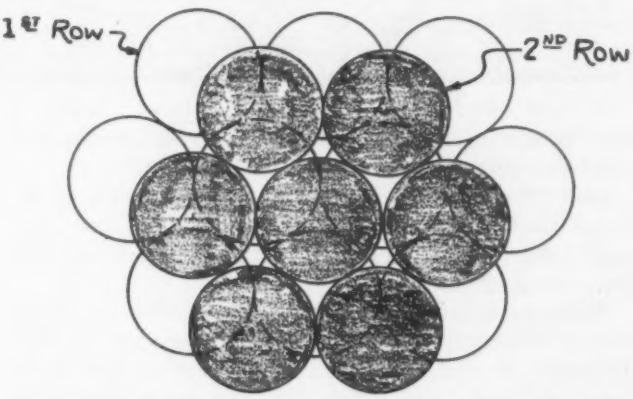

Fig. 4–Rhombohedral packing showing continuous rhombohedral voids resulting from the third row placed or oriented the same as the first row.

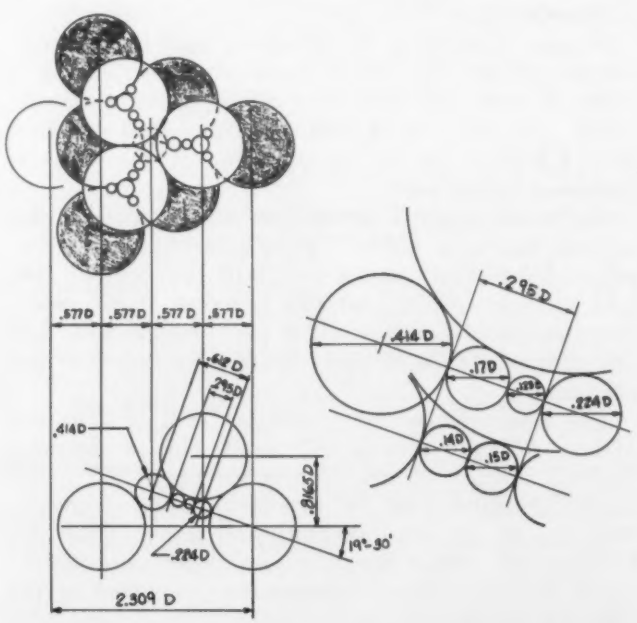

Fig. 5–Determination of large rhombohedral. Void sphere size (void spheres do not position structure spheres as do key spheres) and two combinations of filler size.

TABLE 6 – RELATIVE VOLUMES VARIOUS SUPPORT BALLS

	Cube Ball	Support Balls		
		Dead Center		Multiple
Diam	D	0.268D	0.261D	0.22D
Volume	1	0.0193	0.0177	0.01064
Number	1	1	0	0
Number	1	0	2	2
W %	100	1.93	0	0
	100	0	3.54	2.13

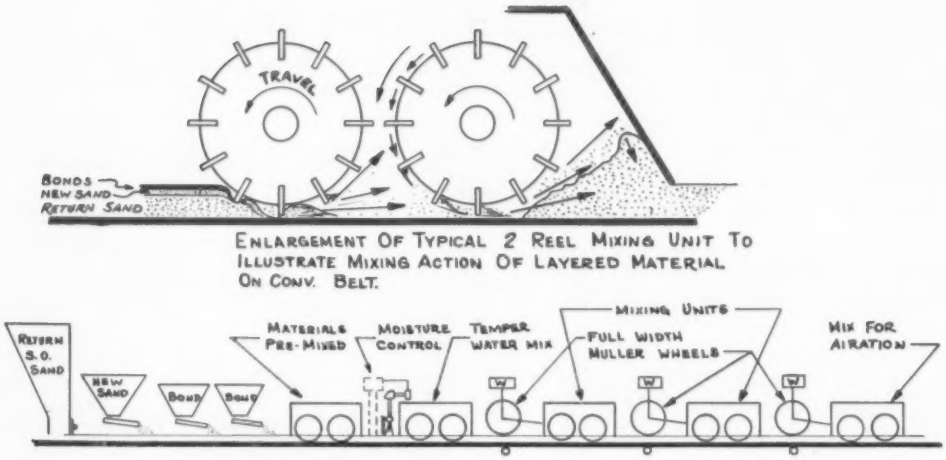

Fig. 6 – Continuous conveyor belt molding sand preparation unit.

cent consisting of 0.12 per cent of 200 mesh, and 0.442 per cent of 370 mesh.

The 100 mesh cubes requiring support balls of 0.00158 to 0.0022 need approximately 0.41 per cent consisting of 0.06 per cent of 270 mesh and 0.35 per cent of 325 mesh.

The total amount of material required for support balls is 0.03 per cent of 140, 0.28 per cent of 200, 0.5 per cent of 270, and 0.352 per cent of 325. Sufficient material is available for this requirement, as there is 2.3 per cent of 140, 4.42 per cent of 200, 0.76 per cent of 270, and 0.80 per cent of pan. This can be assumed to contain the 0.35 per cent of the 325 mesh required.

Surplus material over and above that used for formation of the triple set of three component cubes is 6.86 per cent, consisting of 2.27 per cent of 140 mesh, 4.14 per cent of 200 mesh, and 0.45 per cent pan. Effective use of 91 per cent of the mass is indicated on this basis.

Use of the multiple set of four support balls in the amount shown in Table 7 gives a combined requirement of 0.46 per cent of 140, 0.10 per cent of 200, 1.34 per cent of 270, and 1.54 per cent of 325 mesh. The available material is 2.3 per cent of 140, 4.42 per cent of 200, 0.76 per cent of 270, and 0.80 per cent pan.

The shortages consist of 0.6 per cent of 270, and at least 0.75 per cent of 325 mesh. This is assuming that all of pan material is equivalent to 325 mesh. These shortages can be expected to be overcome with use of the molding sand, and are probably related to the initial break-in period required before all of the desirable properties are developed in the Schumacher 4-screen sand[1].

CONCLUSION

Cubical calculations of several other published sand-screen analyses were made and are shown in Table 2. The data is limited. However, it indicates that for high-strength, low-expansion, sands compounded cubically from adjacent screens the potential volume percentage of the first or largest cube size should be less than 20 per cent.

Mixing and Uniformity

The improved casting quality, and yields obtained by careful selections of base-sand grain size proportions, serves to emphasize the requirements of sand preparation and handling systems for maintenance of this high performance level. Base sands formulated from balanced adjacent screens will have a minimum tendency to segregate during handling dynamics. Thorough mixing is required to obtain random distribution of sizes to permit early formation of a maximum volume of ordered packing during molding.

Basically, sand preparation consists of two separate phases, 1) mixing, and 2) mulling.

Mixing

The objective of mixing is to thoroughly distribute all ingredients so that any volume increment of the mass will have the proper proportions of sand grain sizes, clay, water, etc. This mixing objective is best obtained in two steps, the first being to pre-mix all ingredients at a low moisture level when the mixture has a high flowability as compared to the tempered condition.

Sayer and Marek[1] show that water alone will cause two or more grains to become positioned together through molecular friction and surface tension forces. This condition, at temper, hinders random distribution. It is overcome by the addition and mixing of temper water in a second mixing stage. The thorough distribution of clays prior to addition of temper water will promote the formation of more uniform clay films on grains. This is done by utilizing the molecular carrying forces associated with the water.

TABLE 7 – PER CENT SCREEN WEIGHT OF 1 CENTRAL SUPPORT BALL (0.268D) FOR 50-70-100 MESH CUBES

Mesh	Support Ball Mesh				Total %
Cube	140	200	270	325	
50	0.32	1.6	....	....	1.93
70	....	0.38	1.55	....	1.93
100	....	....	0.23	1.31	1.54

TABLE 8 – PER CENT SCREEN WEIGHT OF A SUPPORT UNIT CONSISTING OF A PAIR EACH OF 0.261 D AND 0.22 D BALLS

Mesh	Support Ball Mesh				Total %
Cube	140	200	270	325	
50	4.6	1.06	....	....	5.66
70	....	....	4.6	1.06	5.66
100	....	....	....	4.6 Max	4.60

Variable heavy to light clay concentrations present when temper water is added can produce a similar variation in clay films on the grains. This will happen unless thorough unrestricted mixing follows a condition of this kind.

Mulling

After semi-dry pre-mixing of ingredients, followed by mixing in temper water, mulling is required to produce continuous clay films around grains that are not readily wet by water. The sliding and rolling action of the grains during mulling promotes removal of these unwettable films. This permits formation of a molecularly tight thin clay coating. The formation of uniform clay coatings beyond the thin base-film thickness is subject to variable local pressures. This is because plastic flow will occur between contacts.

H. W. Meyer[11] determined that medium to thinly uniformly clay-coated grains are required. The impossibility of having all sand grains coated alike was mentioned. This highlights one of the points where improved sand preparation can be of benefit.

Under ideal conditions, the mulling energy required should be consumed on a volumetrically uniform basis. Then any volume increment such as 1 cu in. taken from any location will have its proportionate share of the total-consumed energy. Use of full width mulling wheels is considered a major development for obtaining this objective.

Molding Sand Preparation

Following are the authors' opinions for improving molding sand preparation.

A continuous belt type mixer muller (Fig. 6), as shown by Dietert Fig. 30; [5], has the necessary flexibility to apply the ideal mixing and mulling principles. The material is fed onto the belt in layers to suit the desired proportions. Pre-mixing is done rapidly with all of the material receiving the same uniform action. The time required for mixing is not a factor. There is only a small volume or batch increment present, which is slid off by one mixer blade. The proportioned layers reduce the mixer duty requirement, and permit uniform treatment at a large tonnage rate.

Water and/or slurry additions are made with high velocity sprays across the sand width. This is followed by a second mixing station. This distributes the water prior to compaction by the first mulling wheel. This wheel, which may be variably weighted to correlate with green strengths and shear movements, is full width. All of the material volume is treated. The speed of the muller wheel is approximately 20 per cent faster than the belt speed. Slide movements of grains over and above that occurring by normal compressive shears are increased.

Repetitive mixing and mulling stations are used to suit belt speeds, tonnages, and molding sand specifications. The exit station is a mixing unit to aerate the sand for good flowability and high permeability. Clay films that are not uniform because of pressured areas during prior compaction are given the freedom to spread back into the deficient localities.

SUMMARY AND CONCLUSIONS

1. Suitably balanced adjacent screen distributions of grain sizes prevents the formation of either rhombohedral or rhombic types of packing.
2. Typically good sands show a repetitive pattern of cubes formed from the mean sizes of adjacent screens.
3. Strong cubically-compounded structures require three grain sizes for each cube size present to form a supplementary continuous sand network parallel to the cube grain axes.
4. The exceptionally good propertied Schumacher 4-sieve sand shows 91 per cent of the mass to be tri-cubic structure, with each cube composed of at least 3 grain sizes.
5. High strength low-expansion sands compounded cubically from adjacent screens should have less than a 20 per cent volume of the largest cube size.
6. A parallel type of progress for sand preparation is to separate the mixing and mulling phases so greater efficiency and effectiveness can be obtained.
7. Mixing for greatest effectiveness should be done in two stages. First—pre-mixing in a semi-dry flowable condition, and second—mixing for uniform distribution of temper water and formation of clay films.
8. The application of full mixing and mulling energies to small successive volume increments permits a high degree of uniformity.

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AN IMPROVED DESIGN FOR CAST TENSILE BAR MOLDS

By

Maurice Karnowsky*

ABSTRACT

A commonly-used tensile bar mold design covered in Federal Test Method Standard Number 151 (formerly QQ-M-151) was examined for flow characteristics by pouring water in a lucite replica of a sand mold.

The experiment indicated that the design promoted turbulence from a number of sources:

1. Trapped air at the chokes.
2. The unfilled runners.
3. The comingling (co-mingling) of the incoming metal stream with that returning from the end of the runner.
4. Unequal pressure buildup resulting in unequal filling of the tensile bar cavities.

Principles of gating design as developed by Eastwood and others, under AFS sponsorship, were applied to this design and executed in lucite for the mitigation of these four problems.

For this double gated mold the changes embody incorporation of the following principles.

1. The 1-6 ratio of sprue base area to total runner.
2. Large radii at any change of direction.
3. In multiple in-gates, each area to be its fraction of runner area.
4. The runner cross sectional area was reduced successively by amounts equal to the in-gate area.
5. A five per cent increase in runners and in-gates for frictional losses at each change of section.
6. All runners are in the drag and in-gates in the cope where possible.

Measurements of the flow from each tensile cavity, slides, and a film show the inadequacies in the QQ-M-151 mold and their amelioration in the improved mold design.

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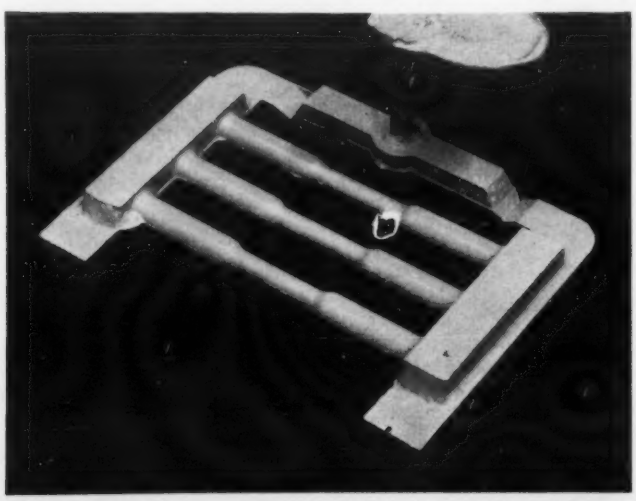

Fig. 1—Tensile bar casting as per Federal Test Method Standard No. 151. Hats on tensile bar, riser, and pouring basin are not specified. The risers (modified) have been removed.

EVALUATION BASIS

Cast tensile bars are widely used as a basis for evaluating the quality of aluminum melts. The validity of such evaluation depends upon the assumption that cast tensile bars accurately reflect the quality of the pour. Observations made in the author's company threw considerable doubt on this basic assumption. This led to the design of an improved mold for cast tensile bars.

Since the making of cast tensile bars is a repetitive operation, the molds used are generally thought to embody ideal design principles not always attainable in the mold used for the regular pour. As a result, the properties of the bars are expected to excel those of the rest of the pour. Observations made at the author's company, with one of the tensile bar mold designs suggested by Federal Specification QQ-M-151 and later by Federal Test Method Standard No. 151, dated July 17, 1956, revealed the following conditions:

1. Although the tensile bar fracture showed dross, X-ray films rarely indicated dross in the casting poured concomitantly.
2. Shear strength and tensile strength among the three bars varied as much as ten per cent.

Films of water trials in lucite molds, made by Battelle Memorial Institute with funds from the AFS, suggested a method of studying the problem. The tensile bar cavity suggested by QQ-M-151 was duplicated in lucite. This was so that observations of water trials could be made to learn how the design of the mold might contribute to the production of turbulence and dross.

The mold replica (Fig. 1) corresponds to Fig. 6, Method 211, Federal Test Method Standard No. 151, July 17, 1956. The pouring basin is not specified. The recommended sprue and pouring basin were not used

Fig. 2—Cope assembly of FHM No. 151 bar showing jams which hang from the cope.

in the lucite replica because of the difficulty of keeping the sprue filled. The cope and drag sections of the replica were machined from acrylic resin.

The gage lengths of the tensile bar cavity were cut through so the volume of flow through each cavity could be measured. Details of the cope assembly with dams are shown in Fig. 2. The drag assembly is shown in Fig. 3. The entire test assembly with leveling stand, drains for each cavity, drag, cope, sprue, and stoppered pouring basin is shown in Fig. 4.

A series of water trials made with the lucite replica resulted in the following observations. Some portion of the column of air trapped between the water falling through the sprue and the bottom of the well swirled in the well as small bubbles. Some of the bubbles spilled out to the dams where the rolling action of the water carried them on into the runners. Figure 5 illustrates this accumulation of bubbles in the runners at the end of 5 sec.

Observation of the flow of water in the runners showed they are never filled above the parting line. The water flows from the sprue to the far end of the runners, and backs into the bar cavity farthest from the sprue. The middle, and then the closest cavities are filled, successively. At the dams, turbulence was noted at two points in the runners: first, at the far end of the runners where the flow is stopped and reversed; second, at the entrance of the far tensile cavity where fluid backing away from the end of the runner and entering the cavity intersects the flow from the sprue.

The flow from each of the cavities was measured with the results shown in Table I. The consistency of the flow percentages indicates that there is a pressure gradient as a result of the runner design.

SUMMARY

Observation of the lucite model of the QQ-M-151 bar mold design showed the following:

1. Air bubbles clean up slowly in the well.
2. Turbulence is induced by the chokes or dams.
3. The runners are never full, offering opportunity for bubbles to be entrapped by the flow.
4. The design of the runners induces turbulence at two points.

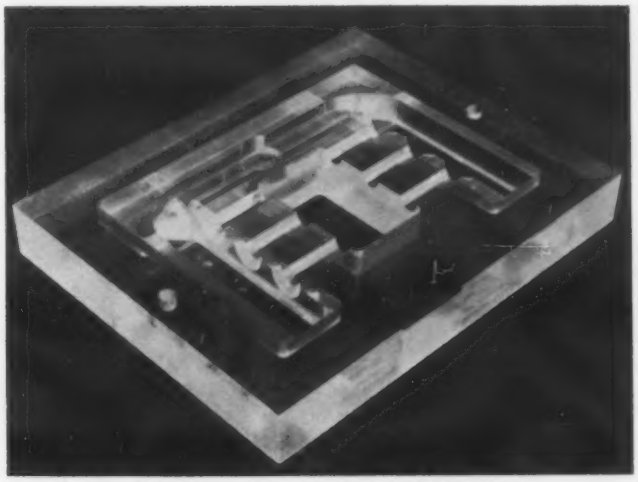

Fig. 3—Drag assembly of FTM No. 151 bar mold.

5. Fluid flow is unequal in the three cavities.

Since the turbulence in the runners, and the irregularity with which air escapes from the mold, could account for variations in the dross characteristics of the tensile bars produced from such a design, an attempt to construct an improved mold was made. Runner design has been studied by a number of investigators. The following principles, developed by Eastwood[1], were used in this attempt:

1. Large radii should be used for direction changes.
2. Runners should be in the drag and ingates in the cope when possible.

[1]Symposium on Prinicples of Gating, AFS, Chicago, 1951. "Tentative Design of Horizontal Gating Systems for Light Alloys," p. 29.

TABLE 1 – PERCENTAGE FLOW IN EACH CAVITY

Duration of flow, sec	Near cavity, %	Middle cavity, %	Far cavity, %	Flow rate, cc/sec
6	25.6	33.4	41.0	110
12	23.7	33.0	43.3	161
18	25.0	32.2	42.8	152
24	25.0	33.5	41.5	163
24	26.1	32.5	41.4	150
30	25.6	32.7	41.7	153
48	25.5	32.5	42.0	155
60	24.5	31.8	43.7	181

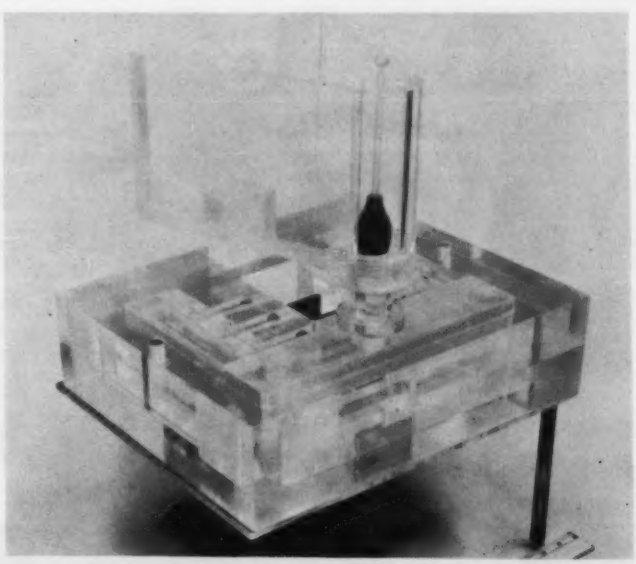

Fig. 4—Entire assembly with stand, individual drains, cope, drag, sprue, and stoppered pouring basin.

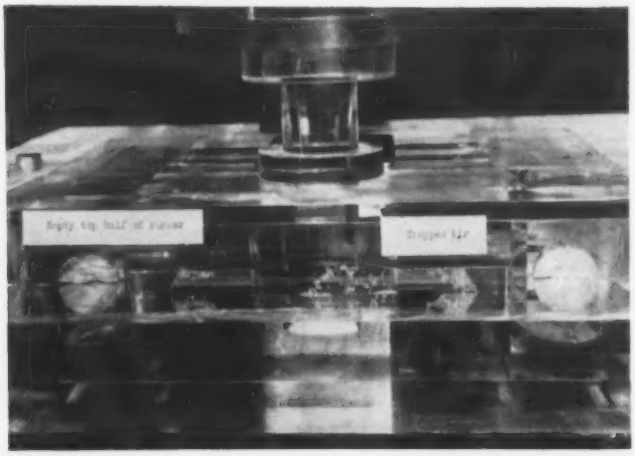

Fig. 5—Above—The accumulation of air at the jams at 5 sec is shown in the FTM No. 151 bar mold.

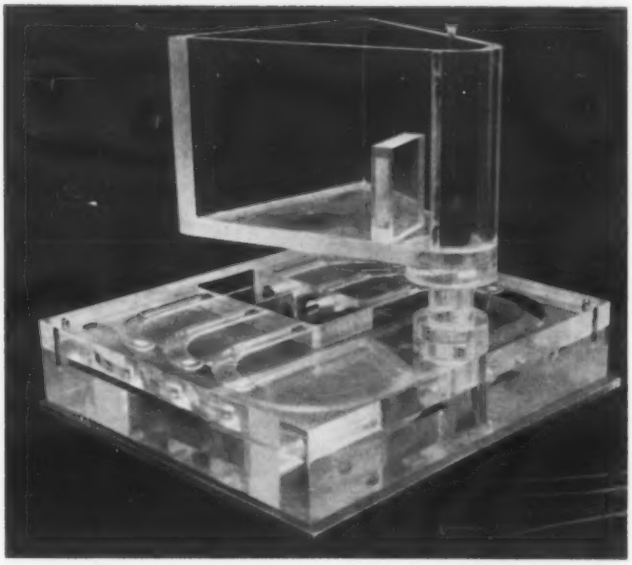

Fig. 8—Right—Entire improved mold assembly showing pouring basin, sprue, cope, drag, and individual drains.

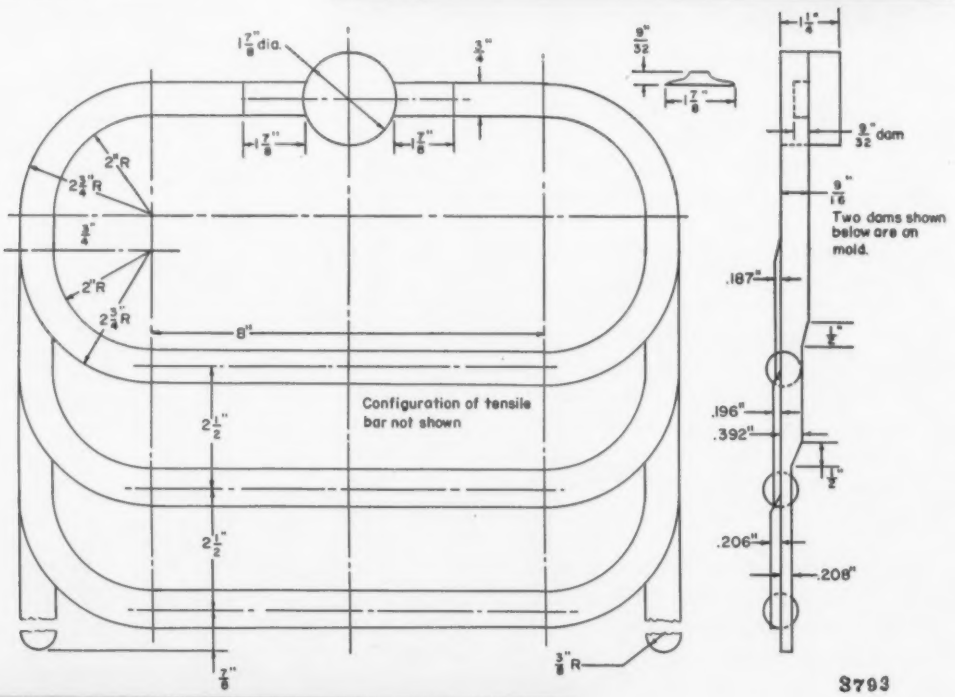

Fig. 6—Sketch of improved tensile bar.

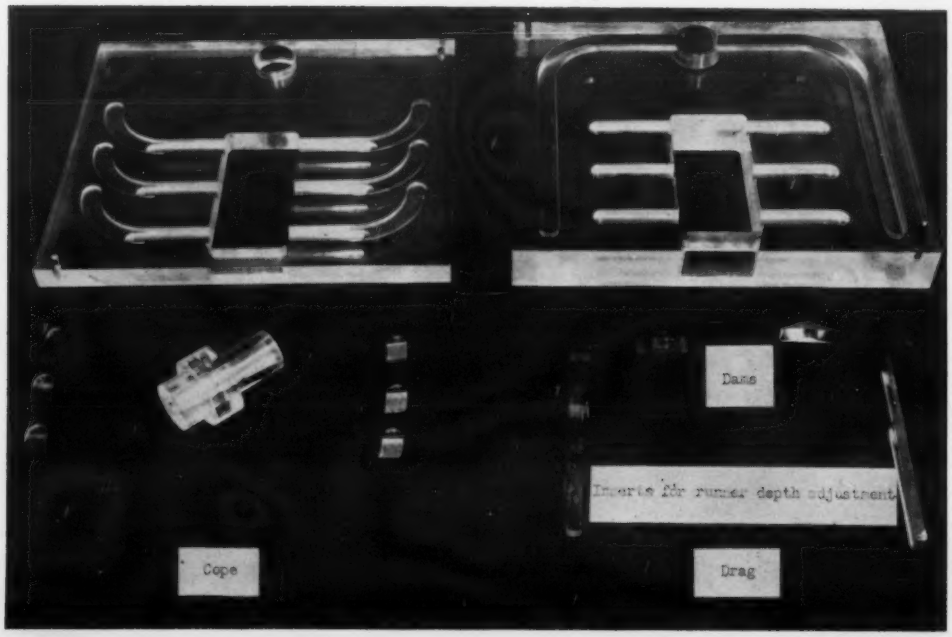

Fig. 7—Revised tensile bar mold following Eastwood principles using 2-in. radii and system for decreasing runner area after passing in-gates.

3. The total cross sectional area of the runners in a two-runner system should equal 6 times the bottom area of the sprue. (In a single runner system, the runner area should equal four times the area of the sprue.)
4. In a multiple-gate system, each in-gate area should be equal to its fraction of the runner. For example, if there are three in-gates in a single-runner system, each in-gate should have an area 4/3 the sprue area.
5. As each gate is passed, the cross-sectional area of the runner should be reduced by an amount equal to the area of the in-gate.
6. Five per cent should be added to the in-gate dimensions for each reduction in the cross-sectional area of the runner to compensate for increased friction.

These principles were applied to the conventional test bar mold. The new configuration is shown in Fig. 6, 7, and 8.

The author's foundry makes use of tapered sprues, 3/4-in. square at the top and 3/8-in. square at the bottom. These dimensions determine that in a two-runner system the cross-sectional area of each runner should be: 3 x 3/8 x 3/8-in. = 27/64 sq in.

Assuming a runner width of 3/4-in., the depth of the runner becomes 9/16-in. The well diameter is 2-1/2 x the width, or 1-7/8-in. The recommended well depth is equal to the runner depth. At each side of the well, dams were placed in the drag to reduce the area by one-half. The dams are 2-1/2 times as long as the runner is wide and are smoothly contoured.

Beyond the first in-gate, the area of the runner is reduced by the area of the in-gate or in this case by the sprue base area. At this point, the runner area is: $A = 1.05 \times (27/64 - (3/8)^2) = 0.294$ sq in., yielding a depth of 0.392 in. The area of the in-gate for the second cavity is 1.05 times that of the previous in-gate area. Between the second and third in-gates, the runner area equals 1.05 x (0.294 – 9/64) or 0.161 sq in. Since the width is kept constant at 3/4-in., the depth is 0.214 in. The runner was extended beyond the third in-gate to provide a dross trap, and a volume in which to dissipate some of the kinetic energy of metal in motion.

The flow from the mold of this design is tabulated in Table 2.

Table 2 indicates that flow uniformity has been improved. Figure 9 shows the comparative performance of the two molds. Observations of the mold with water flowing showed nonturbulent flow in the channels.

The tests described above were made with water. Because of the differences in gravity and viscosity between water and aluminum, the relationship between water trials and the actual behavior of aluminum remained in question. Some work was done on this problem.

E. V. Polyak and S. V. Sergiev reported in *Comptes Rendes Du Academe of Science* USSR 30, 137-9, 1941, on work in which viscosities of two molten aluminum alloys were measured at various temperatures. At 1350 F, which is close to the usual temperature at which tensile bars are poured, they measured the viscosity of 12 per cent silicon alloy at 2.1 centipoise. This viscosity is the same as that of a 31 per cent glycerine solution.

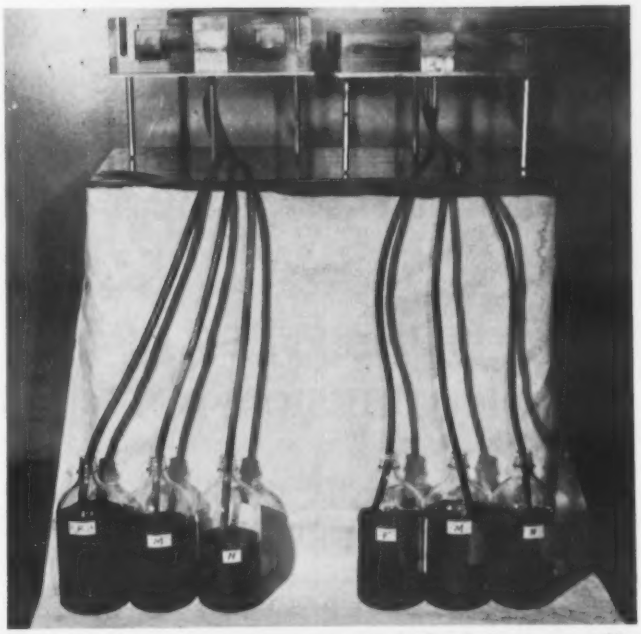

Fig. 9—Comparative performance for each of the two molds. Nearly uniform flow is from the improved bar.

TABLE 2 – PER CENT OF FLOW THROUGH CAVITIES

Duration of flow, sec	Near cavity, %	Middle cavity, %	Far cavity, %	Flow rate, cc/sec
6	31.8	37.0	33.3	112
12	29.4	36.0	34.5	136
18	31.6	35.2	33.2	136
24	31.7	35.1	33.0	141
30	31.4	34.8	33.8	157
36	32.4	34.2	33.5	156
48	31.3	35.8	32.8	156
60	32.7	35.5	32.0	159

TABLE 3 – FLOW THROUGH CAVITIES IN BOTH MOLDS USING GLYCERINE SOLUTION

	Old mold %	New mold %
Near cavity	25.3	32.6
Middle cavity	33.9	35.1
Far cavity	40.8	32.4

Trials were made in both molds with the glycerine solution. The results are tabulated in Table 3.

It is believed that redesign of the tensile bar mold design can be said to have achieved the following:

1. Turbulence caused by the dams has been relieved.
2. Turbulence caused by the runner design is reduced.
3. Unfilled runners permitting oxidation of the metal have been eliminated.
4. Nearly equal filling of the cavities from each of the in-gates has been accomplished.

These improvements were achieved by reducing the runner after each ingate and using large radii for every direction change. The validity of the water trials was in part validated by tests run with the glycerine solution.

THE EFFECT OF SOME GASES ON THE WORK OF ADHESION BETWEEN A NOVOLAK AND QUARTZ

By
Denis W. G. White* and Howard F. Taylor**

INTRODUCTION

A shell mold is fabricated from a refractory metal oxide in particulate form, usually silica sand, bonded with a thermosetting phenolformaldehyde resin. The sand and the resin are intimately mixed before the aggregate is discharged onto a pattern; but in order to produce satisfactory structural rigidity in the mold or shell, it is necessary to apply heat. When heat is applied the resin polymerizes or sets up.

Until the resin has substantially polymerized it is chemically reactive, especially when it is hot. The hot fluid resin contains many chemically-unsaturated bonds which, when the resin is polymerized will be cross linked one with another but which, until the resin has polymerized, will be available for reaction with any other chemically-reactive substances which may be present. Any such extraneous chemical reactions will degrade the resin, that is, they will interfere with the proper course of polymerization. Changes in the polymerization behavior of the resin can be expected to lead to changes in the bond strength between the resin and the granular metal oxide.

When a shell mold is made, four gases are commonly present in appreciable quantities: nitrogen, oxygen the water vapor as the principal constituents of air; and ammonia released by the breakdown of hexamethylenetetramine (the hardening agent) during polymerization of the resin. These gases may react with the resin and affect the bond strength between the resin and the particulate refractory.

Furthermore, in a very general way, it is possible to predict that the four gases may be adsorbed on the resin and/or absorbed by the resin, and that they are apt to be adsorbed on the surfaces of the particulate metal oxide. All these effects are likely to influence the strength of bonding.

Hence, the work reported herein was undertaken to study quantitatively, the individual effect of nitrogen, oxygen, water vapor and ammonia on the bond strength between phenolformaldehyde resin and a refractory metal oxide.

The Work of Adhesion

Probably the most obvious experimental method with which to investigate the effect of gases on the adhesion or bond strength between an adhesive, for example resin, and a solid, is the tensile test. Certainly the results of such tests should indicate immediately whether this or that gas increased or decreased the strength of a bond compared say, with the effects of another gas.

For engineering purposes this might be all the information required, but for a better understanding of the mechanisms leading to changes in bond strength, it would be useful to know whether these changes occurred principally through, 1) an interaction between a gas and the adhesive (resin), and the nature of this interaction, 2) an interaction between a gas and the solid (silica sand), and the nature of this interaction. Unfortunately, the data from tensile tests do not readily permit a separation of these possible interactions, and a more fundamental approach to the problem of determining the effect of gases on bond strength was considered to be desirable.

Effects of Gases

For the study of the effects of gases on the strength of a bond, the thermodynamic concept of the work of adhesion is a useful semi-analytical device by which the influence of a gas on the adhesive, in terms of surface tension changes of the adhesive, is separated from the effects of the gas on the solid. The work of adhesion of two substances is the theoretical work required to separate them. If the two substances are regarded as a liquid and a solid, then the work of adhesion may be defined as the energy change involved in replacing one square centimeter of liquid-solid interface by one square centimeter of liquid and of solid covered with at least a monomolecular layer

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Based on a thesis presented by Denis W. G. White in partial fulfillment of the requirements for the degree of Doctor of Science at the Massachusetts Institute of Technology, Cambridge, Massachusetts.

of adsorbed liquid. Formally, this process may be represented by the following equation:

$$W_A = \gamma_{SV} + \gamma_{LV} - \gamma_{SL}$$

where:

γ_{SV} = the surface tension of the solid in equilibrium with the vapor of the liquid (dynes/centimeter)

γ_{LV} = the surface tension of the liquid in equilibrium with its vapor (dynes/centimeter).

γ_{SL} = the interfacial energy at the solid-liquid interface (dynes/centimeter).

It is not possible experimentally to determine either γ_{SV} or γ_{SL} individually, although for certain systems the difference between these two quantities may be obtained by exacting methods. Fortunately, another approach to the evaluation of W_A is available. As Fig. 1a indicates, a force balance around the line of contact between a droplet of liquid freely resting on the horizontal surface of a solid indicates that an equilibrium contact angle will be achieved when:

$$\gamma_{SL} + \gamma_{LV} \cos \theta = \gamma_{SV}$$

where:

θ = the contact angle between the liquid drop and the horizontal solid surface (degrees).

Hence, $\gamma_{LV} \cos \theta$ may be substituted for the difference quantity $\gamma_{SV} - \gamma_{SL}$ in the formal equation for W_A giving

$$W_A = \gamma_{LV} (1 + \cos \theta) \qquad (1)$$

Harkins has defined the work of adhesion somewhat differently as the energy change associated with the separation of one square centimeter of solid-liquid interface to produce one square centimeter each of liquid and of clean solid.[1,2] Thus defined, the work of adhesion must be formally written as:

$$W'_A = \gamma_S + \gamma_{VL} - \gamma_{SL}$$

where:

γ_S = the surface tension of the clean solid (dynes/centimeter) for example, as in a good vacuum.

and γ_{LV} and γ_{SL} remain as previously defined.

It is convenient to rewrite the expression for W'_A in the following way:

$$W'_A = (\gamma_S - \gamma_{SV}) + \gamma_{SV} + \gamma_{LV} - \gamma_{SL}$$

Now the substitution made in deriving equation (1) may be used again to give

$$W'_A = (\gamma_S - \gamma_{SV}) + \gamma_{LV} (1 + \cos \theta) \qquad (2)$$

The term $(\gamma_S - \gamma_{SV})$ is the surface free energy lowering of the solid due to adsorption of vapor from the liquid and/or surface migration of the liquid. It is by no means negligible in magnitude when compared with the second term. Indeed Harkins[1] offers some illuminating evidence on this point to show that the two terms are numerically of the same order of magnitude.

Hence $W'_A \approx 2W_A$

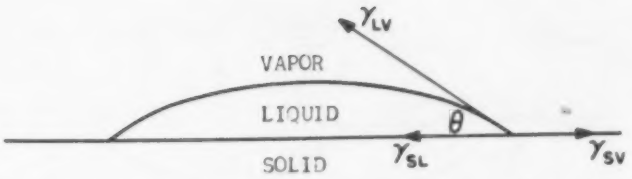

Fig. 1a — A sessile drop in terms of its surface tension forces.

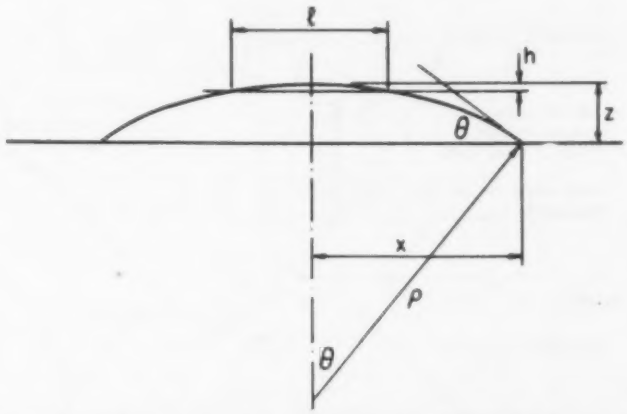

Fig. 1b — The geometrical parameters describing the shape of a sessile drop.

However, because equation (1) describes a process which involves approximately half as much work as the process described by equation (2), then it is reasonable to expect that a bond will fail in a manner more closely related to the former process than to the latter. This argument may be restated in other terms,[3] as follows: ". . . since it is physically impossible to separate a solid and liquid without leaving the solid covered with at least a monolayer in equilibrium with the vapor of the bulk liquid, it is convenient to define the work for such a process . . . ." by equation (1).

The work of adhesion is usually expressed in the units of dynes/centimeter. These units are the dimensional equivalent of ergs/centimeter, which express the concept of work per unit area. Moreover this work is reversible in the thermodynamic sense. Here, the work is the integral of force times distance, where the force is the attraction between the solid and the liquid, and the distance, the corresponding separation of the two substances. As measures by a tensile test, the strength of a bond is expressed in units of force per unit area and this force is irreversible. However, the breaking strength of a bond is probably related to the maximum force of attraction between the solid and the liquid. Hence a correlation between work of adhesion and tensile strength is to be expected only if the area under the force-distance curve varies in approximately the same way as the maximum height of the curve.

Lurie[4] studied the adhesion of polyisobutylene (a tacky adhesive) to eleven different metals and alloys and as a result was able to state that "a definite trend of an increasing work of adhesion . . . . with an increasing interfacial force . . . was found for the (eleven) metal surfaces".

In the present work, a disc cut from a single crystal of quartz was used as a solid representative of

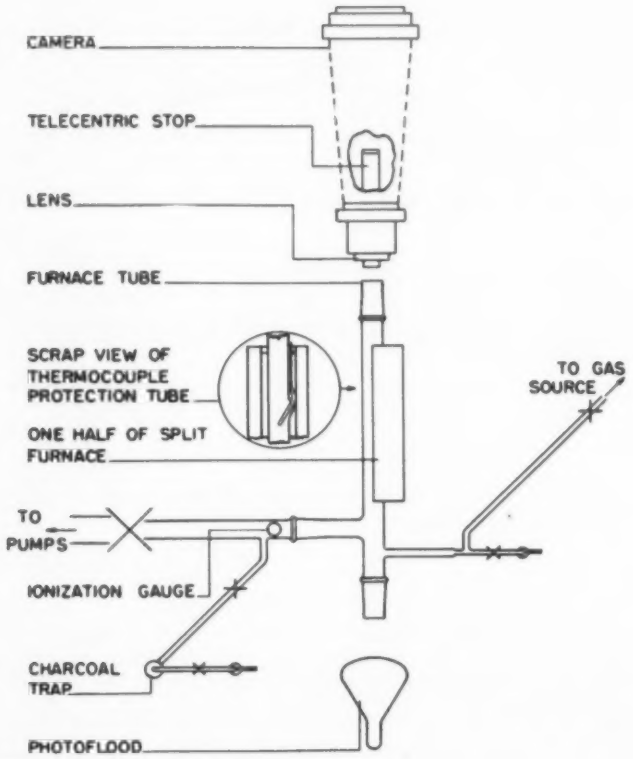

Fig. 2 — Schematic plan of apparatus.

silica sand. This quartz disc had one well polished face in the (01.1) crystallographic plane, parallel to the major rhombohedral face of a natural crystal. With this disc or plaque, the effects of nitrogen, oxygen, water vapor and ammonia on the adhesion of phenol-formaldehyde resin were studied by use of the work of adhesion concept as defined by the equation

$$W_A = \gamma_{LV}(1 + \cos \theta)$$

Method and Technique

There are many methods by which a liquid surface tension may be measured[5] but the sessile drop method is one of the few permitting a simultaneous determination of the contact angle.

Small buttons of resin were melted on the horizontal surface of the quartz plaque at a temperature of 175 C to produce so-called sessile drops. In order to ensure that these liquid resin droplets had assumed an equilibrium shape, so that measurements subsequently made on photographs of the drops would give meaningful values of surface tension and contact angle, it was known to be necessary to hold the resin in a liquid state at 175 C for a number of hours. For this reason, the effects of nitrogen, oxygen, water vapor and ammonia were studied on the adhesion of a novolak to quartz, rather than on the adhesion of a thermosetting resin to quartz.

A novolak is the thermoplastic form of phenol-formaldehyde. With the requisite addition of hexamethylenetetramine to a novolak, a thermosetting resin, as used in shell mold fabrication, would be produced, but at 175 C, this resin would be completely polymerized in 1 or 2 min and would not give an equilibrium drop shape from which valid measurements of surface tension and contact angle could be made.

A schematic layout of the apparatus used for experimental work is shown in Fig. 2. It was designed to isolate the plaque and the resin sample from the surroundings while an experiment was processed through the following four principal stages: 1) to de-gas the plaque at about 500 C in vacuo, 2) to charge the resin onto the plaque when cool, 3) to melt the resin at 175 C and to maintain it at that temperature for not less than four hours (except for experiments with oxygen) in a controlled atmosphere, and 4) to record an accurate silhouette of the drop on a photographic plate.

Among others, Ellefson and Taylor[6] list references to various methods of evaluating the surface tension of a liquid from the measurement of appropriate parameters on the silhouette of a sessile drop of the liquid. However, none of these methods proved suitable for the determination of surface tension from drops having shallow contact angles; i.e., in the region of 30-40 degrees, and large ratios of max. diameter to height. Hence it was necessary to develop some new method for evaluating the surface tension and this was done by using the following equation which is derived and discussed in the appendix:

$$\gamma_{LV} = \frac{\frac{W}{\pi x^2} - D_1 Z}{\frac{2}{g}\left(\frac{1}{b} - \frac{\sin \theta}{x}\right)}$$

where:

W = the weight of the drop (grams)
x = the maximum radius of the drop (centimeters)
D_1 = the density of the drop, to be determined at the same temperature at which the surface tension is measured (grams centimeters^3)
Z = the height of the drop (centimeters)
g = the acceleration constant due to gravity (centimeters seconds^2)
b = the instantaneous radius at the apex of the drop (centimeters)
θ = the contact angle of the liquid on the horizontal solid surface measured through the liquid (degrees).

It was found that if a droplet of thermoplastic resin was held in a fluid state at 175 C for more than a few minutes, small bubbles were apt to precipitate; the lower the ambient pressure the larger were the bubbles able to become. Hence, in order to restrain this effect, all experiments were conducted at one atmosphere total pressure; the composition of the gas, in the general case, being made up of some partial pressure of one of the four gases studied and the balance of purified helium.

RESULTS

1) *Surface Tension and Contact Angle in Purified Helium*

a) Surface Tension

It was possible to evaluate the surface tension in purified helium by means of the Bashforth and Adams[7] Tables as well as by the method developed in this work. The former method gave an average surface tension for two experiments of 54.8 dynes/centimeter,

and the latter method, for the same two experiments, a surface tension of 52.9 dynes/centimeter.

b) Contact Angle

The average contact angle for three experiments was 37.5 degrees.

2) *The Effects of Oxygen*

The cosine of the contact angle and surface tension are plotted in Fig. 3 as a function of the partial pressure of oxygen. The work of adhesion values in Table 1 have been computed with smoothed values of surface tension taken from the graph.

It should be noted that most data in Table 1 have been recorded for a period at 175 C of 2 hr only, in contradistinction to data for other gases which were taken after holding times of not less than 4 hr. From plots of contact angle versus time at 175 C, 2 hr were found to be the minimum time necessary for achievement of equilibrium. At the higher partial pressures of oxygen employed in experiments, as may be seen in Table 1, contact angles increased with increasing time after 2 hr to give results which lacked continuity with the data at lower partial pressures of the gas.

Calculation of the surface tension at a partial pressure of 8.3 millimeters of mercury after 2 hr was possible also with the Bashforth and Adams' Tables. The value thus obtained was 46.2 dynes/centimeter, to be compared with the value of 47.2 dynes/centimeter computed by the method used in this work.

3) *The Effects of Water Vapor*

The cosine of the contact angle is plotted in Fig. 4 as a function of the water vapor partial pressure. The work of adhesion has been calculated upon the assumption that the surface tension remains essentially constant and the average value of 56 dynes/centimeter used for γ_{LV} (Table 2).

4) *The Effects of Nitrogen*

The cosine of the contact angle is plotted as a function of the nitrogen partial pressure in Fig. 5. An average liquid surface tension of 39.5 dynes/centimeter has been used to calculate the work of adhesion in Table 3.

5) *The Effects of Ammonia*

In Fig. 6 the cosine of the contact angle is plotted as a function of the partial pressure of ammonia. An average liquid surface tension value of 63.6 dynes /centimeter has been used to calculate the work of adhesion results given in Table 4.

6) *Confirmatory Results*

Although all of the foregoing data had been obtained from the same sample of novolak, it had not been found possible to gather all of the results from the same batch of reboiled resin. In fact, only the oxygen and nitrogen experiments had been carried out with one batch. For this reason it was considered essential to check the results since it was known that the data for any one gas would be self-consistent and accurate within the prescribed limits, but, with the exception of the results for oxygen as compared with those for nitrogen, not necessarily comparable with the data for another gas.

Furthermore, it seemed desirable to confirm the significant increase in surface tension induced by ammonia and the anomalous behavior of the contact angle as a function of the partial pressure of ammonia when compared with the effects of other gases on the contact angle.

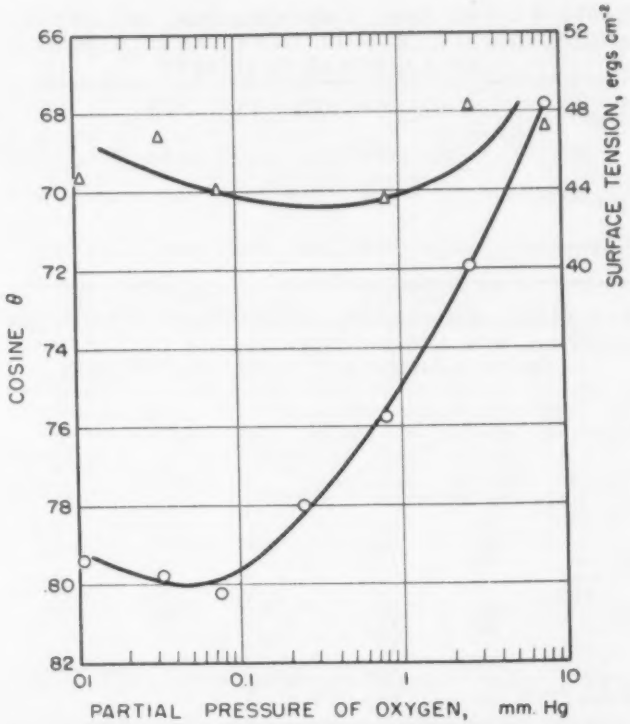

Fig. 3 — The effect of oxygen on the contact angle and surface tension.

This phase of the work was begun with the resin which had been used for data on ammonia (the

TABLE 1 — EFFECT OF OXYGEN ON CONTACT ANGLE, SURFACE TENSION, AND WORK OF ADHESION OF A NOVOLAK TO QUARTZ

P_{O_2} mm Hg	0.011	0.034	0.077	0.25	0.82	2.7		8.3	
Hr at 175 C	2	2	2	2	2	2	3.75	2	3.25
θ	38	37.25	36.5	38.75	41	44	47.25	47.5	55.25
γ_{LV} dynes/cm	44.7	46.8	44.1	35.8	43.6	48.3	41.6	47.2	18.1
W_A dynes/cm	82.9	80.3	79.4	77.4	76.5	78.7	69.8	83.1	28.4

TABLE 2— THE EFFECT OF WATER VAPOR ON CONTACT ANGLE, SURFACE TENSION, AND WORK OF ADHESION OF A NOVOLAK TO QUARTZ

P_{H_2O} mm Hg	0.007	0.069	0.75	5	28.25
θ	22.25	26	28.5	29.75	31.5
γ_{LV} dynes/cm	....	....	53.5	60	54.5
W_A dynes/cm	104.9	106.3	105.2	104.6	103.8

TABLE 3 — THE EFFECT OF NITROGEN ON CONTACT ANGLE, SURFACE TENSION, AND WORK OF ADHESION OF A NOVOLAK TO QUARTZ

P_{N_2} mm Hg	0.021	0.033	0.060	0.577	5.79	61	599.5
$\theta°$	36.5	34.75	33.75	35.25	36.75	38	39.25
γ_{LV} dynes/cm	40.9	41.9	44.8	35.6	43.9	36.8	32.9
W_A dynes/cm	71.3	72.0	72.3	71.8	71.1	70.6	70.1

TABLE 4 – THE EFFECT OF AMMONIA ON CONTACT ANGLE, SURFACE TENSION, AND WORK OF ADHESION OF A NOVOLAK TO QUARTZ

P_{NH_3} mm Hg	0.017	0.025	0.065	0.612	4.72	43	597
$\theta°$	38.5	37.75	34	33.75	33.5	33	33
γ_{LV} dynes/cm	....	64.3	64.1	71.0	61.8	58.4	61.8
W_A dynes/cm	113.4	113.9	116.3	116.5	116.6	117	117

TABLE 5 – COMPARISON OF CONFIRMATORY WITH ORIGINAL RESULTS ON THE EFFECTS OF GASES ON SURFACE TENSION AND WORK OF ADHESION

Confirmatory Experimental Results				Original Results	
P mm Hg	γ_{LV} dynes/cm	W_A dynes/cm	% Change in W_A	P mm Hg	% Change in W_A
Gas H_2O					
0.097	49.6	84.1	+8.5	0.069	+10.0
30	50.6	84.3	+8.8	28.25	+ 7.5
Helium	49.2	77.5			
Gas N_2					
0.079	46	72.9	−5.7	0.060	−25
604	48.4	80.5	+3.2	522.5	−27.5
Helium	49.2	77.5			
Gas NH_3					
0.15	60.2	107.6	+28.1	0.065	+20.4
604.5	65	115	+36.9	527	+21.1
Helium	49.2	84			

last series of experiments) but it was found to give inexplicably high contact angles. Further batches from the same original sample behaved similary and hence, the resin was abandoned entirely. A second sample was reboiled under vacuum and the experiments carried out as planned, (Table 5).

Confirmatory experiments were also run on the effects of oxygen but the results are not included in Table 5 for reasons which will become clear in the discussion section. The value of 49.2 dynes/centimeter for the surface tension of the second novolak sample, given in column 2 of Table 5, is the average of four results. In column 4 the effects of a gas on the work of adhesion are expressed as the percentage change with respect to the work of adhesion obtained in helium. For comparative purposes, the percentage change in work of adhesion compared with that in purified helium is given for the original data in column 6.

It is interesting to observe in column 2 of Table 5, that the significant increase in liquid surface tension occurs as before in the presence of ammonia. However, the anomalous decrease in contact angle, apparent in Table 4 of the data for the iriginal novolak with increasing partial pressure of ammonia, is not confirmed. At a partial pressure of 0.150 millimeters of mercury, the confirmatory experiment gave a contact angle of 38° and a contact angle of 39.75° was obtained at a partial pressure of 604.5 millimeters of mercury.

DISCUSSION

1) *Oxygen*

Of the four gases examined, oxygen is undoubtedly the most potent in its effects; and because of this potency it proved necessary to restrict the studies of its influence to partial pressures of less than about 8 millimeters of mercury. At partial pressures of oxygen greater than 8 millimeters of mercury, sessile drops of the fluid novolak would assume non-equilibrium shapes in less than the 2 hr at 175 C regarded as a minimum time for the achievement of equilibrium.

Moreover, it is apparent in Table 1, that at partial pressures of 2.7 and 8.3 millimeters of mercury, that the liquid surface tension, γ_{LV}, decreases, and that the contact angle increases as a function of time. These changes are particularly severe at the higher of the two partial pressures. However, if the contact angle and surface tension change with time, even from values which at 2 hr have a continuity with other values at lower partial pressures, then these results must be regarded as non-equilibrium and in terms of surface energy measurements, without significance.

Furthermore, from the smallest partial pressures of oxygen studied, the resin drops were found to be enveloped in an orange-colored, acetone-insoluble membrane of tenacity which increased with increasing oxygen concentration. This film adhered firmly to the quartz plaque and was probably composed of the oxidized novolak chains whose identity was determined by Hall.[8] But under the constraint of any film, the sessile drop cannot be considered to be resting freely on the plaque and its measured values of surface tension and contact angle must be regarded as more apparent than real.

Hence, it may be concluded that 1) the presence of oxygen seriously degrades a novolak held at an elevated temperature and 2) since oxygen develops a tenacious film which must constrain a sessile drop, degradation cannot be quantitatively analyzed in terms of surface energies.

2) *General*

The effects of water vapor, nitrogen and ammonia have some features in common which, to avoid repetitiousness, can be discussed collectively. The following equation, previously defined in a slightly different form, is a useful interpretative device with which to pursue the discussion:

$$\frac{\gamma_{SV} - \gamma_{SL}}{\gamma_{LV}} = \cos\theta$$

where:

γ_{SV} = the surface tension of the solid when in equilibrium with a gaseous environment

γ_{SL} = the interfacial energy between the liquid and solid

γ_{LV} = the surface tension of the liquid in the prevailing atmosphere

θ = the contact angle.

Figures 4, 5 and 6 show that the immediate effect of the three active gases is to induce a sharp increase in cos θ. If for the moment it is assumed that the quantity $\gamma_{SV} - \gamma_{SL}$ remains constant, then a sudden increase in cos θ would be a reflection of a sudden decrease in the liquid surface tension (γ_{LV}). The numerical magnitude of the effect, however, is small and well within the limits of experimental error (see Appendix). But, since the behavior of cos θ is initially the same for all of these gases whether they tend to increase the liquid surface tension (for example water vapor and ammonia), or to decrease it (as in the case of nitrogen), then it seems reasonable to believe that

the form of the cos θ versus partial pressure curves is due to a change in the quantity $\gamma_{SV} - \gamma_{SL}$ which occurs whatever other changes γ_{LV} undergoes.

Therefore, initially, either γ_{SV} increases or γ_{SL} decreases. There is no good reason to believe that admission of an active gas to the system should raise the surface free energy of the solid; rather, by adsorption, the gas should decrease γ_{SV}. Hence the initial increase in cos θ should be due primarily to a decrease in γ_{SL}, the interfacial energy between the liquid and solid and it is hypothesized that γ_{SL} decreases because water vapor, nitrogen and ammonia inhibit polymerization.

The formation of small bubbles in a sessile drop is due principally to the slight polymerization which occurs in the novolak when it is heated. In a private communication, Drumm[9] stated it had not been found possible to produce a novolak with a phenol to formaldehyde (P to F) ratio smaller than about 1 to 0.8 which did not show some tendency to polymerize. The "P" to "F" ratio of the resin used in the original experiments, was 1 to 0.86. However, it was observed that whenever the resin was melted in an atmosphere containing a partial pressure of nitrogen greater than about 60 millimeters of mercury or partial pressure of ammonia greater than about 400 millimeters of mercury, no bubbles occurred. These observations are adduced as evidence that nitrogen and ammonia certainly, and, at sufficient concentrations, water vapor probably too, inhibit polymerization completely.

If the effect of these gases is to progressively repress polymerization with increasing gas concentration, then a reduction in steric hindrance and cross-linking among the novolak chains may be expected to accompany the effect. Thus the resin will become increasingly amenable to the force fields in the solid surface until it saturates them, and hence, γ_{SL} decreases.

The continued increase in cos θ over the entire range of ammonia concentrations studied is anomalous (Fig. 6). It is not substantiated by the confirmatory experiments which indicate a decrease in cos θ in conformity with the linear decrease in the same parameter for water vapor and nitrogen as shown in Figs. 4 and 5. The effect is believed to be associated with the degradation of the resin discovered subsequently.

The continuous decrease in cos θ as a function of gas concentration (after the initial increase) finds a logical explanation in the progressive reduction in γ_{SV} due to adsorption of gas on the solid (quartz) surface.

3) *Water Vapor*

The effects of water vapor were studied only up to partial pressures of the order of 30 millimeters of mercury since higher concentrations would have condensed on the cooler parts of the apparatus. Even so, this represents about the maximum concentration of the gas likely to be found in industrial practice.

Water slightly raises the surface tension of a novolak, and increases the work of adhesion approximately 10 per cent when compared with the values of surface tension and work of adhesion obtained in purified helium. The effect can probably be ascribed to the polar nature of the water molecule.

4) *Nitrogen*

Compared with the surface tension and work of adhesion of a novolak in purified helium, nitrogen

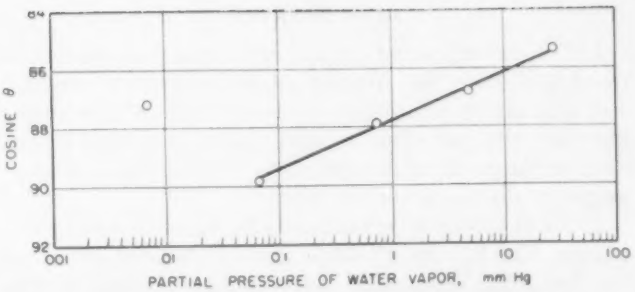

Fig. 4 — The effect of water vapor on the contact angle.

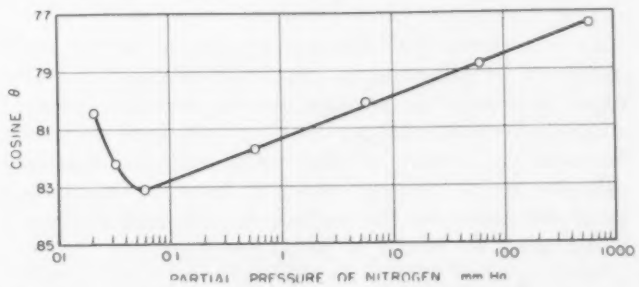

Fig. 5 — The effect of nitrogen on the contact angle.

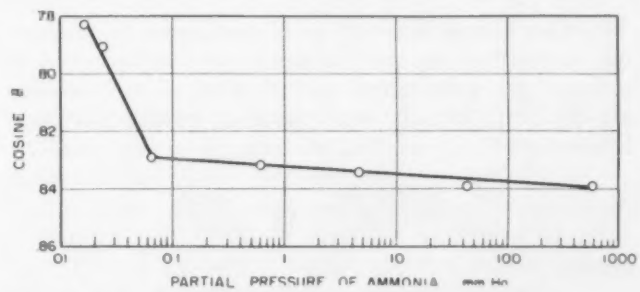

Fig. 6 — The effect of ammonia on the contact angle.

reduces these quantities by an amount which is in some doubt. It is not clear whether the decrease in surface tension is due to adsorption or to the formation of non-polar groups with the novolak chains.

5) *Ammonia*

Ammonia increases the liquid surface tension (γ_{LV}) of a novolak by about 20 per cent and the work of adhesion by about 20 to 30 per cent when compared with the values obtained in helium. These increases are appreciable and suggest the presence of dissociated compounds, that is, ionic groups, of ammonia perhaps with free phenol or traces of the catalysing acid.

PRACTICAL IMPLICATIONS

The work draws attention to the desirability of fabricating shell molds in the absence of oxygen. The degradation effects of this gas are undoubtedly serious and although it is reasonable to object that degradation does not begin to assert itself at partial pressures of the order of 8 millimeters of oxygen until the resin has been molten for at least 2 hr, it should be borne in mind that the partial pressure of the gas ordinarily present in the atmosphere is about 20 times as great. Oxygen may very well react with a thermosetting resin in shell molds in the two or three minutes during which the resin is hot, to an extent that is worth curtailing.

CONCLUSIONS

1) Traces of water vapor, nitrogen and ammonia quickly reduce the contact angle between a novolak and quartz, by inhibiting polymerization of the resins but the principal effect of subsequent increases in gas concentration is to progressively increase the contact angle by adsorbing on the solid.

2) Of the four gases whose effects were examined, oxygen had the most potent and deleterious influence on the resin. However, as was determined in this work, it is not possible to describe the effects of oxygen quantitatively in terms of surface energy measurements.

3) Compared with the surface tension of the resin and work of adhesion in purified helium, (a) water vapor increases the surface tension and the work of adhesion by about 10 per cent, (b) nitrogen decreases the surface tension of the resin and the work of adhesion by an amount which is in some doubt, (c) ammonia increases the surface tension and the work of adhesion by about 20 to 30 per cent.

APPENDIX

Bashforth and Adams[10] have developed the following expression for the surface tension of a liquid in terms of the geometrical and physical factors describing the form of a freely resting or hanging drop as follows:

$$\frac{1}{\rho} + \frac{\sin\theta}{x} = \frac{2}{b} + \frac{gD_1Z}{\gamma_{LV}}$$

where:

- x = the horizontal coordinate of any point in a meridional section of the surface of the fluid (centimeters)
- Z = the vertical coordinate of such a point (centimeters)
- ρ = the radius of curvature of the meridional section at that point (centimeters)
- θ = the angle which the normal to the surface makes with the axis of revolution (degrees)
- b = the radius of curvature at the origin of the axis of revolution (centimeters)
- D_1 = the density of the fluid (grams cubic centimeters)
- g = the acceleration due to gravity (centimeters/second)
- γ_{LV} = the surface tension of the fluid (dynes/centimeter).

Figure 1b illustrates a drop in terms of the above geometrical parameters. "x", "Z", and θ can readily be measured and if the volume of the drop can be determined, D_1 may be computed when the weight of the fluid is known.

The variables remaining to be determined are the radii ρ and "b". Of these, "b" is the more amenable to direct measurement than ρ.

However, the volume of a drop may also be expressed in terms of the above variables[11], as follows:

$$V = \frac{\gamma_{LV}\pi x^2}{gD_1}\left(\frac{1}{\rho} - \frac{\sin\theta}{x}\right)$$

Since $V = \frac{W}{D_1}$

where W is the weight of the fluid (grams), then

$$W = \frac{\gamma_{LV}\pi x^2}{g}\left(\frac{1}{\rho} - \frac{\sin\theta}{x}\right)$$

Substitution for V in the original expression for γ_{LV}, after algebraic manipulation, leads to the equation,

$$\gamma_{LV} = \frac{\frac{W}{\pi x^2} - D_1Z}{\frac{2}{g}\left(\frac{1}{b} - \frac{\sin\theta}{x}\right)}$$

Only "b" now remains to be determined, and since the crest of the meridional section of a drop exhibiting a shallow contact angle may be approximated over an appreciable arc by a curve of invariant radius, Pythagorean geometry indicates that,

$$b = \frac{h}{2} + \frac{l^2}{8h}$$

where "l" is the length of a chord on the meridional section intersecting the radius of curvature about the axis of revolution (centimeters), and "h" is the vertical coordinate from the chord to the origin.

Liquid Surface Tension Error Analysis

Estimated measurement error limits for l ± 0.002 centimeters

Estimated measurement error limits for h ± 0.0005 centimeters

Error limits in surface tension due to l and h = ± 2%

Estimated measurement error limits for x ± 0.0005 centimeters

Estimated measurement error limits for Z ± 0.001 centimeters

Error limits in surface tension due to x and Z = ± 2.5%

Estimated measurement error limits for θ ± 1°

Error limits in surface tension due to θ = ± 6%

Total comparative error ± 10.5%

Estimated weighing error for W = ± 0.0002 grams

Error limits in surface tension due to D_1 = ±0.5%

Total absolute error ± 11%

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INDUSTRIAL APPLICATIONS OF OLIVINE AGGREGATE

By

Gilbert S. Schaller* and W. A. Snyder**

INTRODUCTION

The mineral olivine was first discovered in 1790 by Johann Gottlieb Werner. He named this mineral olivine because of its olive-green color. The first recorded attempts at using crushed olivine as an aggregate in synthetic molding sand was in a Norwegian steel foundry in 1927-28.[1] This use in the foundries followed the discovery in 1925 by V. M. Goldschmidt that natural olivine and olivine rock (dunite) had valuable properties as a refractory.

This discovery led to intensive studies since olivine is found abundantly in Norway.[2] Literature on the early use of olivine in foundries comes from Norway exclusively. The objective was that of finding a material of hygenic value that would overcome the silicosis problem among foundry workers.

Olivine is currently being introduced into Swedish industry on a broad scale. The Domnarfvets Jernverk entirely changed over its steel foundry operations to olivine in August, 1957. In addition, Kanthal and Kohlswa Jernverk are other foundries that have gone over to olivine. These adoptions have not been made without incident and certain difficulties which have been successfully resolved.

OLIVINE STUDIES

An extensive series of studies on olivine is being conducted by the Swedish Institute for Metal Research under the direction of Prof. Erik Rudberg, Director.[3] Among the problems under study are the possibility of the development of free silica at the metal-mold interface. Their studies are not yet complete, and for that reason have not been published.

Olivine has been studied extensively at this University in the Department of Mineral Engineering. The department has published upwards of a dozen papers and theses on olivine properties, evaluations, and potential applications in areas other than for foundry aggregate. In order to understand the material it seems desirable to review a few fundamentals.

Olivine is a solid solution of forsterite and fayalite. The ratio of these constituents is not fixed. In consequence, only those deposits that can produce the material containing approximately 90 per cent forsterite minimum are considered as a satisfactory source of olivine foundry aggregate. The sand obtained by crushing this material has a high-fusion point and a low uniform thermal expansion.

Olivine grains show a remarkable ability to withstand thermal shock without cracking or shattering. On the other hand, such sands weigh approximately 25 per cent more when rammed into a mold than does silica. They have a slightly greater cooling effect, and exhibit a higher heat capacity than silica. The grain shape is angular and acts to control the rammed density of the mold.

For several years past the Mechanical Engineering Department of the University of Washington has been investigating the use of olivine as a foundry aggregate. Throughout this research the foundry of the Mechanical Engineering Shops has served as a pilot operation. The sand for these studies has been obtained from the Twin Sisters deposit in the Mount Baker area of the Cascade Mountains in the State of Washington. Olivine sands from other deposits in the state and other regions of this and foreign countries were examined. However, only materials from the Twin Sisters area have been used in the intensive research programs.

The olivine of this deposit is in the form of massive mineral that must be crushed and classified in order to produce a manufactured aggregate (sand). The sands used for early research were produced with improvised equipment in many grain sizes and distributions. The primary objective of this research was to determine the aggregate sizes that would be of greatest value to commercial foundry operations.

A series of commercial sands prepared from the Twin Sisters olivine deposit are now prepared on a commercial scale. They are available to the industry. These sands are supplied as numbers 45, 70, 130, and 200. The identifying numbers correspond to the AFS fineness number of the aggregate. Since the aggregate is a manufactured product it is subject to control,

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TABLE 1 – NON-FERROUS SAND FORMULATIONS

Constituents parts/wgt No.	A	B	C	D	E
130 Olivine	54	93	20	90	..
200 Olivine	40	..	76	..	..
115 Silica	..	..	..	..	90
W. Bentonite	1	..	3	2.5	2.5
S. Bentonite	5	7	4	2.5	2.5
Wood Flour	..	..	..	..	2.0
Water content/%	3	3.2	3.4	3.0	3.0

and therefore, the grain size and distribution should be reliable and constant.

A substantial number of foundries seeking to improve their product or reduce their costs have investigated the application of olivine sands in their operation. In many cases the advantages shown by this aggregate have caused its adoption. The objective of this paper is to review a few of these operations where superior castings or an economic advantage over previous sand practice have resulted from the introduction of olivine.

NON-FERROUS APPLICATIONS

Natural molding sands constitute the bulk of the material currently used in this area. These sands can produce excellent results, but those that produce a good surface usually require a high-moisture content and have a low permeability. Only a minor portion of the non-ferrous foundries have used synthetic sands, although many have expressed the desire to obtain the advantages that they offer.

A major deterrent to the use of synthetic sand is that they usually require the addition of organic buffer materials to eliminate expansion defects. This is not a difficult problem where facing sand is employed, but requirements are rarely sufficiently critical to justify the added cost.

Organic materials in heap or system sand present an extremely difficult control problem. Olivine based synthetic sands without organic material additives have proven successful in this connection. If the moisture content is correctly controlled, these sands may be hard rammed without causing either steam or expansion problems.

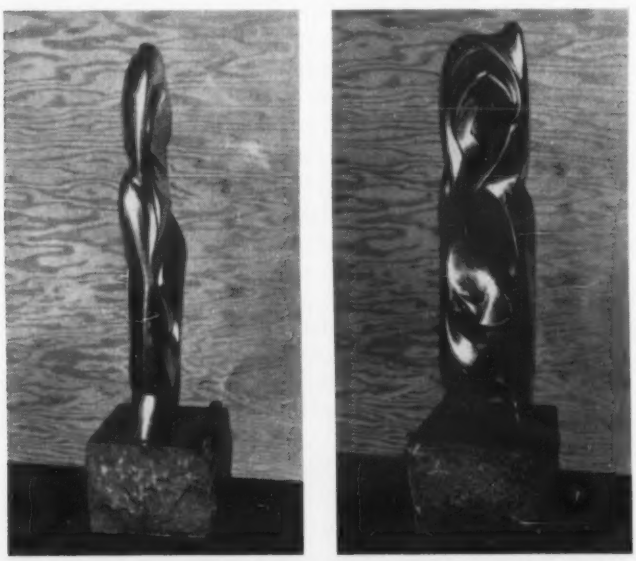

Fig. 1—Two views of aluminum alloy statue cast in olivine. (Courtesy De Freece Foundry)

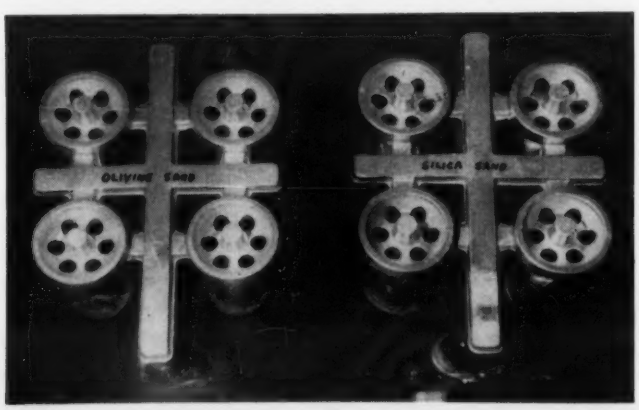

Fig. 2—Casting group at left molded in olivine. Group on right cast in silica-based molding sand. (Courtesy Boeing Airplane Co.)

THERMAL PROPERTIES

The thermal properties of these sands are instrumental in producing a smoother surface than would normally be expected for a given permeability. Table 1 shows some formulations that are presently being used by commercial foundries.

Mixture A is employed by a mechanized aluminum-alloy foundry. Mixture B is used to produce green-sand molds for thick-sectioned brass and bronze castings for marine service. Mixture C is used by a jobbing foundry for an extensive range of green-sand work for both aluminum alloys and brass. An aluminum statue which is not cored and was molded in mixture C is seen in Fig 1. The statue weighs 65 lb and is cast from aluminum alloy No. 43.

Non-ferrous foundries that have converted to olivine have usually changed at the same time from natural molding sand to synthetic. A few foundries, however, have shifted from synthetic silica sand to synthetic olivine sand. One of these is the Aluminum Foundry, Industrial Products Division of the Boeing Airplane Co., Seattle.

This foundry has used the sand shown as mixture E in Table 1 to produce the sound, high quality castings required for their applications. This silica foundation contained 2 per cent wood flour additive in order to eliminate expansion defects. To produce large flat castings, a special facing had to be prepared to which an additional 2 per cent of organic material was added to prevent formation of rat tails. This sand has been replaced entirely by mixture D of Table 1. This is an olivine molding sand containing no organic material used to produce all castings without facing.

Similar castings produced as part of a test program at Boeing with the two sands are seen in Fig. 2. The olivine sand in this test has a slightly higher permeability, but produces a smoother surface. The grain size of the aluminum casting produced in olivine was slightly finer as a result of faster solidification, although both casting sets were of acceptable quality.

Most non-ferrous operations report that the life or durability of the olivine sands has far exceeded their expectations. Such sands cannot be introduced satisfactorily unless the foundry is equipped with a sand muller. This requirement is the greatest single factor in limiting wider application in non-ferrous foundries.

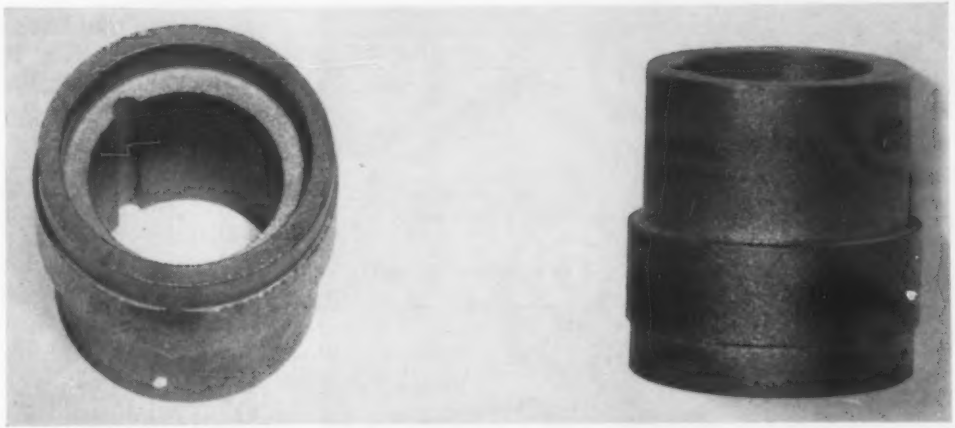

Fig. 3—Views of gray-iron casting molded in olivine shell without a core.

SHELL-MOLDING APPLICATIONS

Shell molds in olivine were made at the University of Washington immediately following the introduction of the process in this country. Other researchers later became interested in this sand for resin-bonded shells, because it was felt that the desirable thermal properties would produce shells of greater accuracy than silica by eliminating or reducing shell warpage. It was further believed that the increased cooling effect would improve the surface finish of castings produced in olivine shells. Incidentally, shells were also evaluated for the production of carbon-steel castings which could not be consistently cast with acceptable surfaces in silica shells.

Olivine shells produced quality castings in the carbon steel. The angular grain, however, offered enough resistance to the flow of sand that low density ramming occurred along vertical surfaces and in pockets. Foundries in the Oakland Bay area solved the flow problem by using olivine aggregate in combination with round-grain silica. Table 2 shows a mixture that has been developed for dump box shell molding.

A basic theoretical fault of the shell mold is that the sand in the pattern cavity is heated and expands when the metal is poured. The shell at the faying surface is not heated and does not expand. This condition causes the shell in the pattern cavity to buckle outward. The resultant buckling in turn forms cracks on the outside of the shell. These cracks can be observed, and their formation timed, if a shell is not hidden by backing material. The least damaging result of the expansion is a distorted casting. A cylindrical casting parted along its axis will tend to become oval. A heavier casting could form fins or even run out if backing is not provided.

These difficulties cannot be entirely eliminated, but they can be reduced by using an aggregate with a lower coefficient of thermal expansion. The addition of as little as 20 per cent olivine to a silica sand will result in a noticeable increase in crack formation time. The mixture given is now considered to give the optimum compromise between adequate thermal properties and acceptable flow properties.

The shell molders using this sand point out that it produces smooth castings with improved accuracy and allows larger castings to be produced without the use of backing materials. Peel-back, which had already been reduced to a minimum through the use of improved binders, is now virtually eliminated with this sand mixture. This result is believed to be from the grain distribution and shape rather than the properties of the aggregate. As this paper is being written, angular olivine grain has not been satisfactorily coated, and so has not been used for the production of shell cores.

An iron casting made in a shell of the material previously described is shown in Fig. 3. The casting is made in a cup-shaped mold with the inside being formed by part of the mold. No core is used. The resulting casting is evidence that the flow properties of the mixture are proving to be excellent. A group of castings made in the olivine shells are pictured in Fig. 4. Gray iron, steel, brass, and bronze castings comprise this grouping.

GRAY CAST IRON APPLICATIONS

Much of the original research devoted to olivine sands in this country was performed through the medium of gray cast iron. These studies indicated that olivine can be instrumental in reducing expansion defects with little or no added organic buffer materials. The permeability of an olivine heap is not

TABLE 2 – SHELL-MOLD MIXTURE

Constituent parts/wgt No.	Compositions lb
100 Silica	20
70 Olivine	40
130 Olivine	40
Resin Binder	6

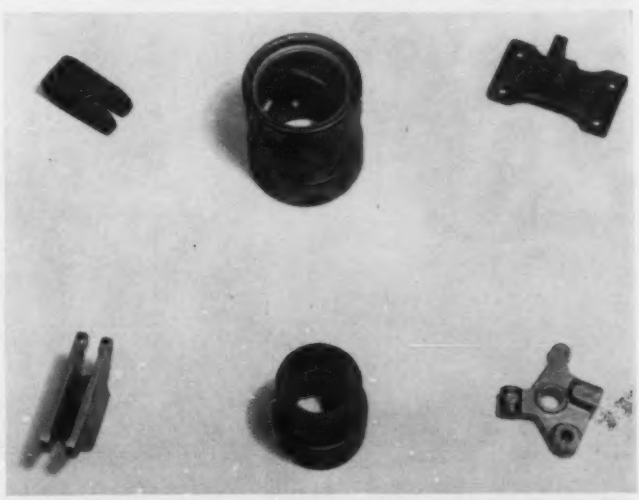

Fig. 4—Castings made in olivine shells.

TABLE 3 – GRAY IRON MIXTURE

Constituent parts/wgt	A	B
70 Olivine	95	..
130 Olivine	..	94
W. Bentonite	5.00	4
S. Bentonite	..	2
Corn flour	0.4	..
Water %	2.8	3.0

TABLE 4 – GREEN-SAND MIXTURES FOR STEEL CASTINGS

Constituent parts/wgt No.	A	B	C	D
45 Olivine	..	42	300	300
70 Olivine	95	42	200	300
140 Olivine	..	..	..	..
200 Olivine	..	10	25	..
W. Bentonite	5	6	30	30
Corn flour	.5	1.5	2	2
Dextrine	.25	..	44	4
Water %	3.2	5.0	4.3	3.5

reduced by use, except through the addition of new clay or other additives. This is because the grain is not fractured by thermal shock. The excellent life of the sand will eliminate facing from many molds.

Olivine mixtures somewhat similar to those used for non-ferrous work can also be used to replace natural molding sand for light and ornamental iron castings. The thermal properties of the sand can be useful in improving the dimensional accuracy of gray iron castings, and in eliminating center-line shrink when this defect is caused by mold expansion or deformation. Several commercial foundries are using these sands on a trial basis to determine the economic value of olivine to their operation. Mixtures A and B of Table 3 are typical ones used by gray foundries.

Fig. 5–Low alloy steel marine propeller. (Courtesy N&S Foundry Co.)

STEEL APPLICATIONS

Late in 1957 olivine was being used in the field of steel (carbon and low alloy) only in areas where properly formulated silica-sand facings were not giving satisfactory results. Olivine is currently used as a facing backed by the silica-system sand for steel casting productions. The favorable thermal properties that have been mentioned in previous applications are equally advantageous in steel casting. However, the high fusion point of olivine in this field is significant.

Formulating silica-sand facings in the steel foundry has been elevated through extensive research and unlimited field experience to a high degree of perfection. In most cases suitable silica-sand facings will give satisfactory results. Olivine facings will give equally good results with less organic matter. In some cases it gives good results with no organic matter or additives in the formulation.

This fact alone does not give olivine an economic advantage when used as a facing. However, olivine can show a decided advantage when accuracy, penetration, and center-line shrink or cracking caused by mold deformation are problems. Olivine will reduce scabbing and buckling difficulties, but when these defects occur due to poor control, they will not necessarily be cured through the expedient of changing the aggregate.

One commercial steel foundry that is a regular user of olivine for special problems, holds the belief that if their system sand were olivine they could eliminate the use of facing in many of their molds. Such procedure would also greatly reduce the amount of new or reclaimed sand required where facing is used. This condition would seem to result from the reduction of additive required, and from the excellent thermal life of the olivine grain.

Should this assumption prove correct, olivine would offer a decided cost advantage for general steel-casting work. Such a possibility must be investigated by a steel foundry, running a carefully controlled side floor of olivine. This investigation should not be attempted until further field experience with facings determines the absolute minimum additive requirements. Mixture A from Table 4 is a formulation that is used for steel casting in green-sand molds.

A low-alloy steel marine propeller produced by the N & S Foundry Co. of Seattle is shown in Fig. 5. The mold for this casting is faced with no. 70 olivine and contains 5 per cent soluble sodium silicate which is hardened by gassing with CO_2 before the pattern is drawn. The dimensional stability of the olivine has in this case eliminated hub cracks which occurred when silica sand was employed. The accuracy of the blades has been improved. This application has become standard practice at this foundry for many low-alloy and stainless-steel propeller castings.

HIGH MANGANESE-STEEL APPLICATIONS

The greatest interest in olivine sand has been shown by foundries that produce high manganese-steel castings. In some of these foundries the use of olivine facing has become standard procedure. In others the

practice is commonly used, but is as yet considered to be experimental.

In this application, olivine is perhaps the only aggregate available commercially in a suitable range of grain sizes that does not react with the metal. This reluctance of the sand to react chemically at the metal-mold interface has permitted some shops to produce austenitic manganese-steel castings with surfaces that rival expert gray iron production.

The thermal properties of olivine are important here. Foundries have discovered that this aggregate extends the scope of green-sand molding. Many components that have been previously cast in washed- and skin-dried molds can now be produced by the green-sand method. The present practice is limited to the use of olivine facing backed by silica system sand.

With this method of application the obvious advantages are better finish, lower cleaning cost, and where drying is eliminated, lower molding cost. No foundry of this type has converted entirely to olivine, but this step could result in further economies.

Manganese steel dredging buckets (Fig. 6) are produced by the Washington Iron Works of Seattle in their program of evaluating olivine sand. These buckets weigh 142 lb each, and are cast in the green-sand mixture shown as A of Table 4. A manganese steel scraper back made under the same program is shown in Fig.7. This casting was made in a mold faced with mixture B of Table 4. The mold was given an olivine wash and skin dried.

Chrome-manganese cone castings (Fig. 8) were produced by the Electric Steel Foundry Co. of Portland. The casting on the right was made by accepted silica practice. The one on the left was produced with olivine facing. Both molds were washed and skin dried. Mixture C of Table 4 is the olivine facing that was used in this case. Identical manganese steel rope socket castings shown in Fig. 9 were made by this same company. These were poured in green-sand molds. The casting on the left was produced by standard silica practice, while the one on the right used olivine facing. The green-sand-olivine facing mix employed is shown as mixture D of Table 4.

ACCURATE CASTINGS

The application of large, accurate iron and steel castings may soon assume new significance in the production of forming tools for the aircraft, automotive, and missile industries. The tonnage requirements of this market will never be impressive, but the foundries who devote the time and money to developing suitable methods will find this outlet both rewarding and stimulating. Shell molders have frequently expressed a preferance for cast-iron pattern equipment which, for economic reasons, should be cast with suitable surfaces and dimensional tolerance. Olivine is a useful material in the production of this category of casting in green-sand molds.

An accurate gray iron casting (Fig. 10) was produced by a California foundry with the aid of olivine aggregate. The casting is half of a core box for a shell

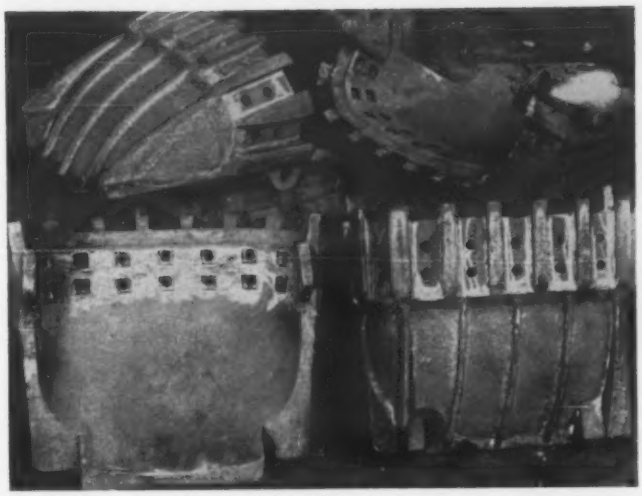

Fig. 6—Manganese dredging buckets made in olivine green sand. (Courtesy Washington Iron Works.)

Fig. 7—Manganese steel backing plate made in olivine dry sand facing, 200 lb, washed and skin dried (olivine wash). (Courtesy Washington Iron Works).

Fig. 8—Drag view—two chrome-manganese cone castings. Left Casting made in olivine sand mold, olivine wash sprayed, torch dried. Right casting made in silica sand mold, silica wash sprayed, torch dried. (Courtesy Electric Steel Foundry Co.).

Fig. 9—Cope view of manganese steel rope socket castings made in green sand molds. Shown in as-cast condition shortly after shakeout. Left, silica sand mold; right, olivine sand mold. (Courtesy Electric Steel Foundry Co.).

Fig. 10—An accurate gray iron half core box used for blowing shell cores.

core blowing operation. This box will be used as-cast, with no machining or finishing of the forming surface. The reverse side of this box casting is ribbed. It was molded in the cope from green heap sand. The formed surface was cast in the drag against a facing mixture composed of 50 parts of No. 100 round grain silica, 50 parts of No. 130 olivine, and 7 parts of a soluble silicate core binder. A minimum gassing treatment with carbon dioxide was followed by baking at 350 F, for 3½ hr.

SUMMARY

Olivine sands from the Twin Sisters area of the Pacific Northwest which have been under intensive investigation as foundry aggregates for several years are now available commercially. Compared to silica, the standard foundry aggregate of this country, olivine offers slightly greater cooling effect, increased heat capacity, uniform thermal expansion, resistance to fracture by thermal shock, and a somewhat higher fusion point. Since olivine sand is a manufactured aggregate it is available in selected grain sizes that can be controlled and reproduced. The sand grains are angular due to the nature of their manufacture.

An increasing number of foundries are investigating the utility of olivine sand in their operation. As a result, further knowledge in the use of this material can be expected. In non-ferrous foundries, complete conversion to olivine aggregates has been effective in both product improvement and cost reduction. The use of olivine facing for high manganese-steel castings has shown economic advantages that are so pronounced as to indicate its adoption as standard procedure.

Commercial shell-molding foundries have devised a method of taking advantage of the favorable thermal properties of olivine. It appears that its use in this process will increase as this potential becomes better known. Olivine facings are being used to reduce costs in iron and steel foundries only in specific instances. Our research indicates that complete conversion by such foundries could result in genuine savings. This has not been proven on a commercial scale, and no complete conversions have been made by late 1957.

Olivine aggregates have become firmly established in certain profitable applications in the United States and Canada. In every instance the adoption has been won in competition with traditionally established materials. The introduction of olivine in America has, in all cases, been predicated on its mechanical and physical properties, with scant attention given to hygenic potentialities. In Scandanavia, where olivine is rapidly becoming the universally accepted aggregate, primary considerations have always been given to its ability to improve working conditions.

In view of the developments and achievements of olivine aggregate it may well be stated that the foundry industry has a material available of proven potential. It can be expected that broader applications and novel uses will follow increasing knowledge and understanding of olivine. In common with a multitude of other materials, there are many types of olivine. The foundryman must remember to select those that have the properties capable of meeting his requirements.

With the increasing interest in olivine by domestic foundries new developments are occuring almost daily. In light of this it can readily be understood that this paper, which was written at the close of 1957, not to be delivered until six months hence, will undoubtedly be contradictory in some instances and outdated in others. Nevertheless, it is felt that basic information contained herein and developed in the foundries is of interest to the industry generally.

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ON THE RELEASE OF HYDROGEN FROM MOLTEN ALUMINUM

By

Asutosh Pal* and H. M. Davis**

INTRODUCTION

Porosity in cast aluminum and its alloys is mainly of two forms: 1) pinhole pores, due to gas evolution, 2) and shrinkage cavities, due to imperfect feeding during solidification. It appears well established that hydrogen is primarily responsible for the pinhole pores.[1,2,3] Various methods have been employed for ensuring melts of aluminum and its alloys have satisfactorily low hydrogen contents when cast. One effective treatment is that of flushing with chlorine. However, the method has a number of operational drawbacks.

Solid sources of flushing gas have been used (volatile and decomposable chlorides).[4] These materials possess the disadvantage of floating on molten metal. The thought of using a dense flushing material in the briquette form to be dropped into the liquid metal is attractive. Obviously, a successful briquette should have certain attributes: 1) it should have a density greater than that of the molten metal, 2) it should decompose or become volatile at metal temperature, 3) it should produce an adequate amount of effective flushing gas at an appropriate rate, and 4) it should produce no contaminants, gaseous or metallic.

An evaluation of many solid substances, organic and inorganic, which might serve as sources of flushing gas resulted in the elimination of almost all of them. They had unsuitable melting point, decomposition temperature, or rate of decomposition, or they yielded objectionable by-products (notably water and hydrogen).

The substance chosen was magnesium oxychloride, Mg_2OCl_2. This substance begins decomposing at a temperature near the melting point of aluminum, and offers little of objectional by-products. Because magnesium oxychloride is of lower density than molten aluminum, it can be made to sink in the liquid metal only if joined with material of higher density.

It became the purpose of this study to investigate the effectiveness of flushing by chlorine released through the decomposition of Mg_2OCl_2 in briquette form which had been weighted with corundum—the dense, high-temperature form of Al_2O_3.

EXPERIMENT

The magnesium oxychloride was made from calculated proportions of MgO, and a concentrated aqueous solution of $MgCl_2$. After the initially pasty product had been dried for 48 hr at 105 C, it had a specific gravity of 1.87. The briquettes were then made from Mg_2OCl_2 and corundum of low iron content. The two materials were blended of such particle sizes that 68 per cent of the briquette was of 60-mesh size and 32 per cent was of 140- to 200-mesh range.[5]

The dry materials were mixed with a small amount of freshly made paste of magnesium oxychloride as a binding addition. They were then pressed into cylindrical briquettes under 10000 psi, with momentary releases at 4000 and 6000 psi. The briquettes were dried for 144 hr at 130 C, suffering a weight loss of approximately 2 per cent. They were kept in desiccators until used. They had a specific gravity of 3.2 in favorable comparison with the value of approximately 2.4 for molten aluminum.

The melting stock used in the experiments was a A.S.T.M. 1100 alloy. The analytical specification for this alloy is shown in Table 1.

The macrostructure of a small ingot of this material is shown at 2X in Fig. 1. As a standard of low porosity, a reference metal was provided of the following composition:

Si	0.06%
Fe	0.17%
Cu	0.01%
Al	Remainder.

This material was from a 100-lb lot had been flushed for 10 min at the rate of 2.8 lb of chlorine per hr. It had a mean density of 2.6901 gram per cc. The macrostructure of this reference metal is in Fig. 2.

TABLE 1 — MELTING STOCK SPECIFICATION

	Max %		%
Cu	0.20	Fe + Si	1.00 max
Mn	0.05	Others	0.15 max
Zn	0.10	Al	99.00 min

Contribution No. 57-30 from the College of Mineral Industries, Pennsylvania State University. From a thesis by Asutosh Pal, submitted in partial fulfillment of the requirements for the Master of Science degree, June 1956.

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**Professor of Chemical Metallurgy, The Pennsylvania State University, University Park.

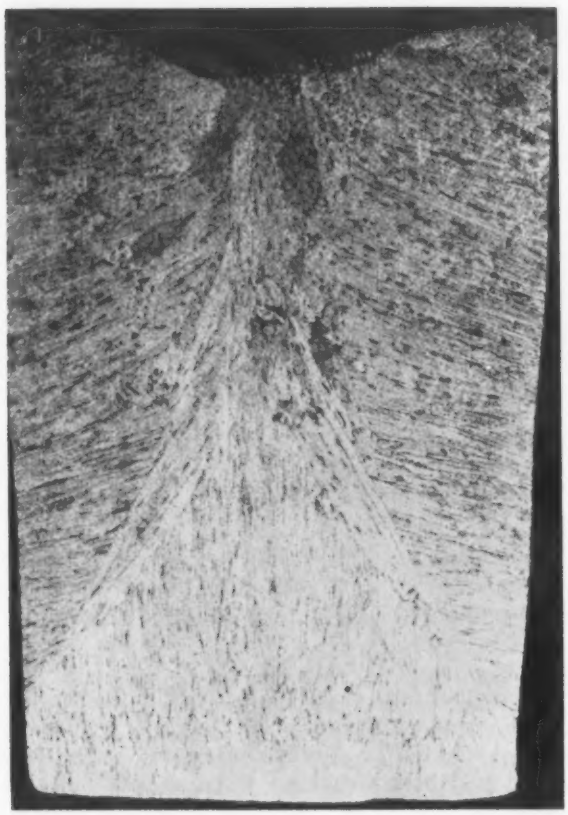

Fig. 1 — Macrostructure of the melting stock. Sodium hydroxide etch. 2×

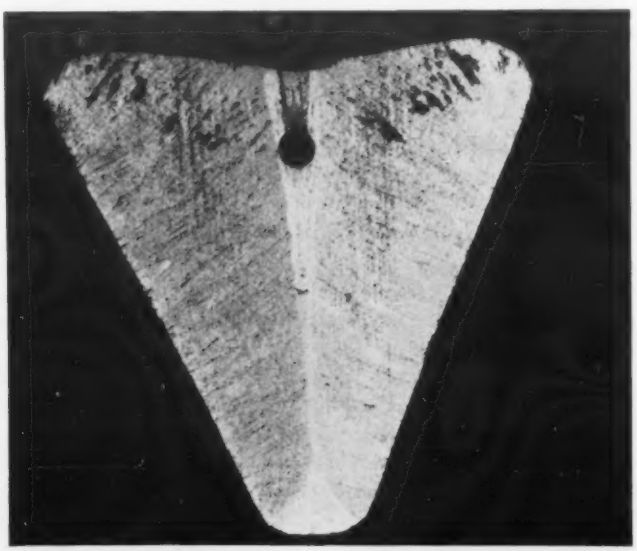

Fig. 2 — Macrostructure of the special reference lot of aluminum. Sodium hydroxide etch. 2×

Five-hundred-gram batches of the melting stock were melted by induction (in air) in commercial magnesia crucibles under graphite lids. All batches were superheated to 900 C, for two purposes: 1) to encourage the absorption of hydrogen, and 2) to permit holding the melts, unheated, for 1.5 min and still having them molten for casting. Some melts were cast, without degassing treatment, into carbon-dressed cast-iron molds preheated to various temperatures. Others, prepared in quite the same way and similarly cast, were first treated with one 28-gram briquette each. These briquettes contained chlorine equivalent to 1800 cc at 900 C, or 1500 cc at a casting temperature of 727 C.

With or without the briquette addition, the metal was held for 90 sec after the heating power was cut off. During this interval, the temperature, initially about 900 C, fell by 115-130 C.

From each cast ingot, specimens were taken for examination of porosity, for determination of density, and for spectrographic analysis.

Densities were determined by use of the principle of Archimedes. The immersion liquid was freshly boiled distilled water for which the variation of density with temperature is known. During weighings, the temperature of the water was continuously followed by use of a Beckmann differential thermometer referred to a secondary standard. Densities to five figures were recorded, although the error may sometimes approximate ± 0.0001 gram per cc.

RESULTS AND DISCUSSION

All the melts were cast into molds which were either cylindrical or dome-shaped, so that the castings were inadequately fed. In consequence, the porosity due to the escape of gas from the freezing metal was exaggerated. Of course, the development of spaces due to shrinkage was also encouraged. The difference between the forms of the pores of the two origins generally permitted their differentiation.

In ingots cast from the briquette-treated melts, the pores were mainly irregularly elongated, angular, or channel-like. They were evidently a product of the shrinkage resulting from imperfect flow of the feeding liquid into interdendritic channels of the growing crystals. Few of the rounded gas-created pores were found in the briquette-treated metal (Fig. 3).

Ingots cast from melts of the same material with no flushing treatment contained an abundance of pores which were round, or somewhat rounded. These were ascribed to the evolution of gas during the solidification of the metal. The substantial absence of the angular or channel-like pores was explained by the assumption that the released gas expanded enough to counteract the shrinkage because of poor feeding during solidification (Fig. 4).

TABLE 2 — DENSITIES OF SUCCESSIVE LAYERS FROM CYLINDRICAL CASTINGS. ODD NUMBERS HAD BRIQUETTE TREATMENT.

Melt No.	6	7	8	9	10	11	12	13
Mold Temp, C	24	24	186	186	300	300	400	400
Layer				Density, gm/cc				
D	2.6631	2.6615	2.6630	2.6612	2.6438	2.6639	2.6391	2.6659
C	2.6619	2.6586	2.6648	2.6644	2.6414	2.6600	2.6318	spoiled
B	2.6653	2.6602	2.6628	spoiled	2.6401	2.6634	2.6226	2.6759
A*	2.6613	2.6545	2.6552	2.6569	2.6305	2.6603	2.6055	2.6741

*Lowest

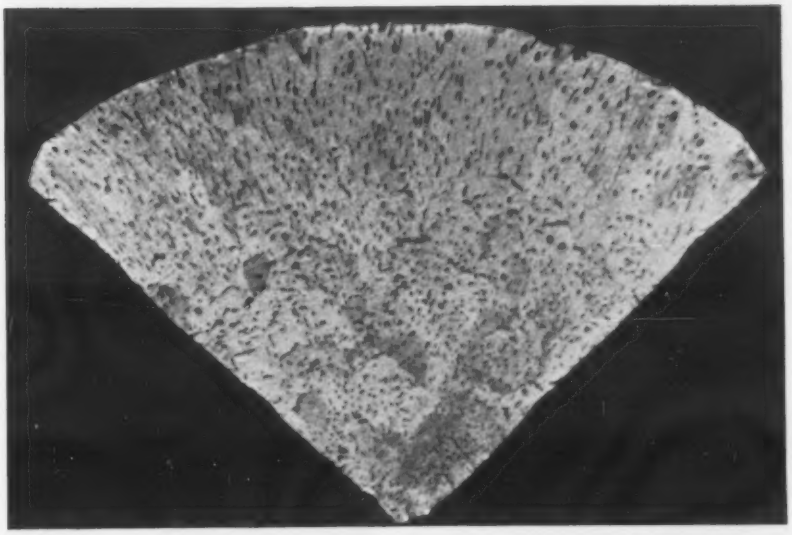

Fig. 3 — Section near bottom of ingot made from briquette-treated melt, cast into dome-shaped mold at 270 C. The irregular, channel-like pores suggest the influence of shrinkage with poor feeding. Sodium hydroxide etch. 2×

The contrast between the form of the pores which apparently were gas-generated, and that of the cavities attributed to shrinkage is further emphasized in Fig. 5 and 6. There sections from the same position in ingots cast in the same mold with and without the briquette treatment, are shown at higher magnification.

Table 2 presents densities measured at four levels in ingots from treated and untreated melts cast into cylindrical molds at four temperatures. The densities shown in Table 2 reveal that, with a given smelting and pouring practice, the density is influenced by the rate of cooling during solidification. The relationship between density and cooling rate is more quickly recognized in Fig. 7. The mean density of each ingot of Table 2 is plotted against the mold temperature. Metal poured from briquette-treated melts attained its maximum density with the slowest cooling. Metal poured from untreated melts was of highest density when it was most rapidly cooled.[6]

This difference in behavior supports the conclusion that the porosity of the treated metal was attributable to the shrinkage attending imperfect feeding. It suggests that a mold providing good feeding and directional solidification toward the feeder head should permit the attainment of higher densities in castings made from briquette-treated metal.

The spectrographic analyses reported in Table 3 disclose that the magnesium content of the briquette-treated metal increased by about 0.006 per cent. It is not known whether that increase was due to inclusions of magnesium oxide, or to the solution of magnesium in the aluminum.

The observed rise in the concentration of magnesium may not be considered objectionable in industrial practice.

TABLE 3 — MAGNESIUM CONTENT OF CAST METAL MELTED WITH AND WITHOUT BRIQUETTE TREATMENT

Melt No.	Treatment	% Magnesium Content	
1	None	0.0039	
		0.0039	0.0036
		0.0030	
2	None	0.0033	
		0.0025	0.0032
		0.0038	
3	Briquette	0.0106	
		0.0098	0.0094
		0.0078	
4	Briquette	0.0080	
		0.0097	0.0088

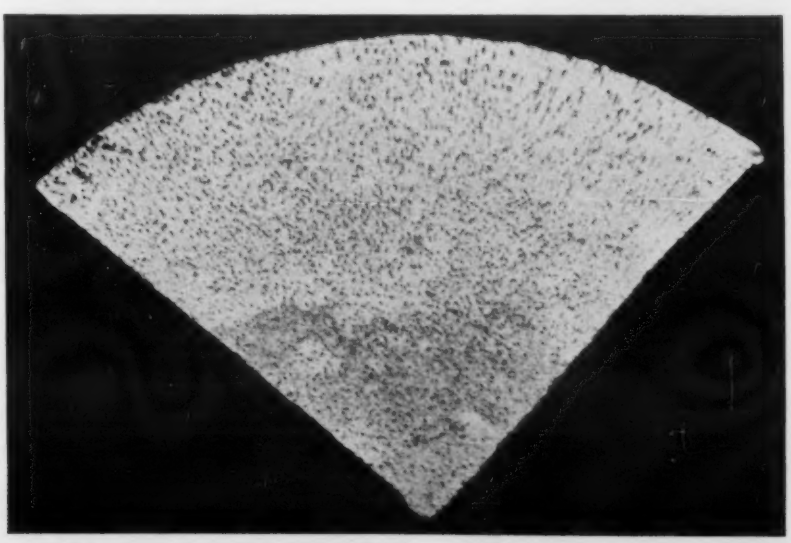

Fig. 4 — Section near bottom of ingot made from untreated melt, cast into dome-shaped mold at 270 C. The predominant, round pores are attributed to the evolution of gas during solidification. Sodium hydroxide etch. 2×

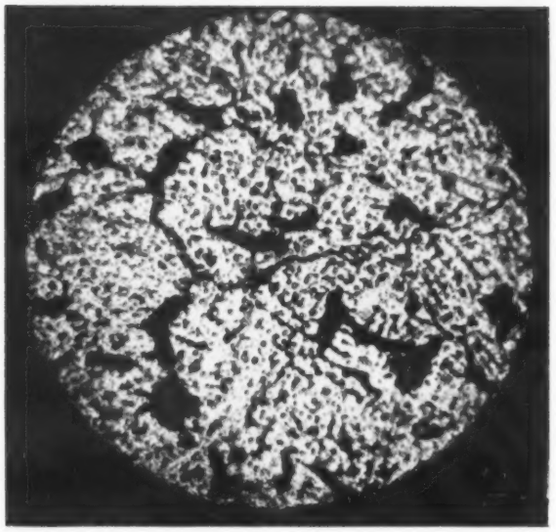

Fig. 5 — Section near bottom of ingot made from briquette-treated melt, cast into dome-shaped mold at 270 C. Irregular forms of shrinkage cavities are revealed. Sodium hydroxide etch. 25×

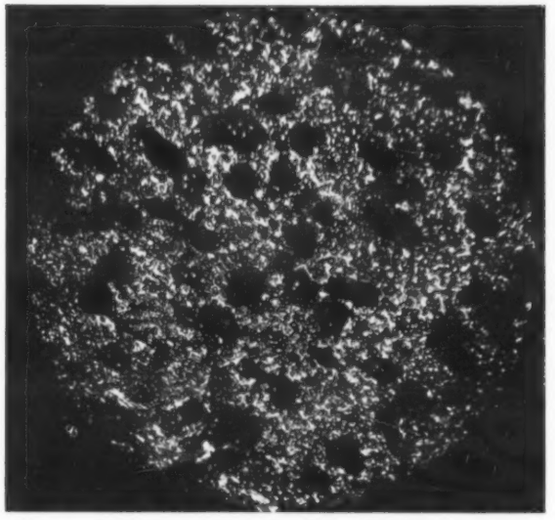

Fig. 6 — Section near bottom of ingot made from untreated melt, cast into dome-shaped mold at 270 C. The rounded forms of gas-created pores are evident. Sodium hydroxide etch. 25×

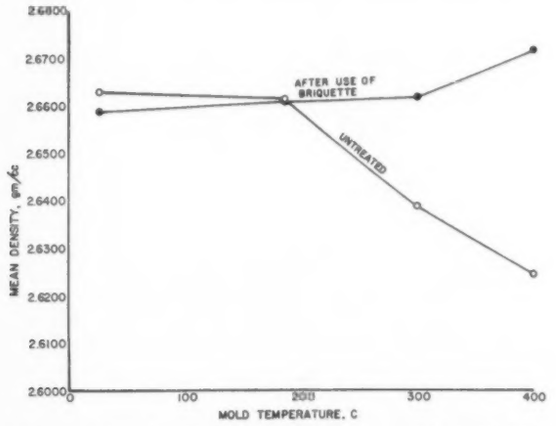

Fig. 7 — Mean density of ingot (Table 2 vs mold temperature. Metal from briquette-treated melts (solid dots) was most dense after slowest cooling. Metal from untreated melts (open circles) was of highest density when rapidly cooled.

CONCLUSIONS

A significant portion of the hydrogen in molten aluminum can be removed by treatment with briquettes containing magnesium oxychloride weighted with corundum.

The decomposition products of the briquettes make no objectionable addition to the aluminum.

In the experiments reported, the porosity of the briquette-treated metal was largely attributable to shrinkage. The corollary is that higher densities could have been attained in the briquette-treated ingots had the feeding been adequate. Unless continued solidification toward the feeding head is realized (mainly through design of the mold), the beneficial effect of the flushing is masked by unsoundness. This results from shrinkage of the imperfectly fed casting.

ACKNOWLEDGEMENTS

It is a pleasure to express our thanks for the metal provided by the Aluminum Company of America and to Mr. J. A. Nock of the Aluminum Research Laboratories.

The helpful counsel of Dr. R. W. Lindsay is gratefully acknowledged.

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Apprentices Show Skill in 35th Annual Contest

Apprentices from Southern California dominated the non-ferrous molding division of the 1958 Robert E. Kennedy Memorial Apprentice Contest by taking the first three places. In addition a Southern California entry placed second in the wood patternmaking division.

Winners in the five divisions of the 35th Annual Contest represented all sections of the United States. A total of 570 entries were received from the United States and Canada.

The winners of the first three places received cash prizes of $100, $75, and $50 and 1st and 2d places had their transportation paid to the Convention and received their awards in person. The first three place winners in each division had their entries exhibited at the Convention.

For the first time in the Annual Contest an epoxy resin pattern, donated by Caterpillar Tractor Co., Peoria, Ill., was used for the molding competition.

This year's competition attracted the second highest number of entries and the greatest chapter and company participation. Eighteen chapters and 151 companies submitted patterns and castings for competition. In the national judging, entries for wood and metal patternmaking as well as steel molding set new highs for competition.

National Apprentice Winners

Paul Niebur, 1st, metal patternmaking.

Raymond McDermott, 1st, iron molding.

James Gift, 1st, steel molding.

William Boatright, 1st, non-ferrous.

Local Chapter Contests

Canton
Central Ohio
Detroit
Michiana
Oregon
St. Louis
Central Illinois
Corn Belt
Eastern Canada
Ontario
Quad City
Twin City
Northern Illinois & Southern Wisconsin
Northeastern Ohio
Philadelphia
Southern California
Washington
Wisconsin

Adam Kravetz, 1st, wood patternmaking.

Winners of the 1st, 2d, and 3d places in the National Competition:

Wood Patternmaking

Adam J. Kravetz, Progress Pattern Co., Pontiac, Mich.
Gerald Celk, John C. Beuse Patterns, Los Angeles.
Edward Lamparyk, Modern Pattern Co., Cleveland.

Metal Patternmaking

Paul Niebur, Central Pattern Co., St. Louis.

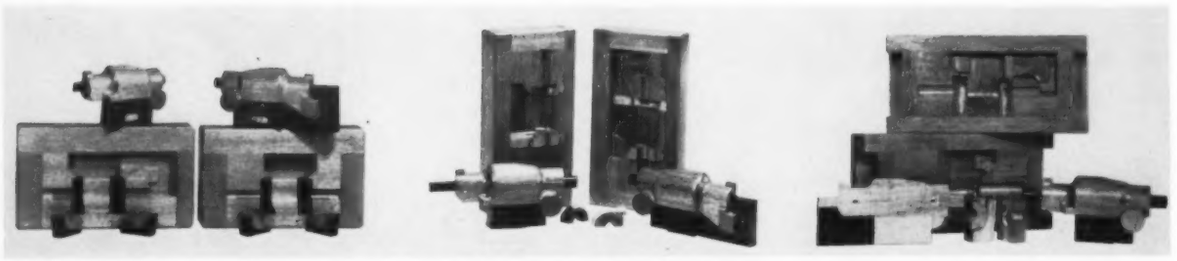
Continued on page 111

AFS 1896

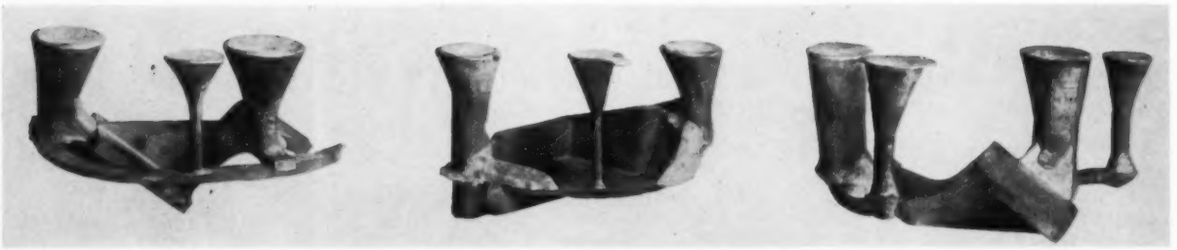
NEWS and VIEWS

Gray Iron Molding Divisions winners.

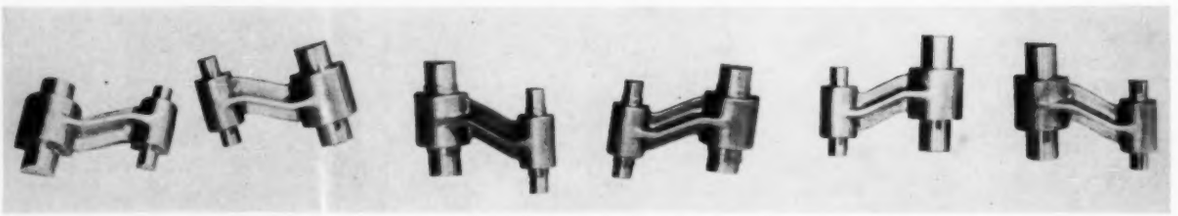
Steel Molding Division winners.



Wood Patternmaking Divisions winners.



Non-Ferrous Molding Division winners.



Metal Patternmaking Division winners.

Picture of Leslie Lowe is not available.

Iron Molding — 2d, James Sanders; 3d, Leslie Lowe.

Steel Molding — 2d, James Rogers; 3d, Gordon Wambold.

Wood Patternmaking — 2d, Gerald Celk; 3d, Edward Lamparyk.

Non-Ferrous Molding — 2d, Loring Thomas; 3d, Ralph Leland.

Metal Patternmaking — 2d, Clifford Duckworth; 3d, Maurice Klante.

Apprentice Contest

Continued from page 109

Clifford Duckworth, Caterpillar Tractor Co., Peoria, Ill.
Maurice Klante, R. A. Nelson Pattern Co., Milwaukee.

Iron Molding

Raymond McDermott, Brown & Sharpe Mfg. Co., Providence, R. I.
James Sanders, Fairbanks, Morse & Co., Beloit, Wis.
Leslie L. Lowe, Caterpillar Tractor Co., Peoria, Ill.

Steel Molding

James E. Gift, Jr., Dodge Steel Co., Philadelphia.
James Rogers, Oregon Steel Foundry Co., Portland, Ore.
Gordon Wambold, Waukesha Foundry Co., Waukesha, Wis.

Non-Ferrous Molding

William Boatright, AiResearch Mfg. Co., Los Angeles.
Loring Thomas, AiResearch Mfg. Co., Los Angeles.
Ralph Leland, Alloy Aluminum Foundry, Los Angeles.

Biographies

Metal Patternmaking

Paul Niebur, 24, worked part time nights in a machine shop before starting with Central Pattern Co. as a trainee in 1956. He became an apprentice in 1957.

Clifford Duckworth, 22, entered a 4-year metal patternmaking course at Caterpillar Tractor Co. in 1954. He has completed his course and works as a metal patternmaker.

Maurice Klante, 27, worked in Milwaukee machine shops for 5-1/2 years before becoming an apprentice patternmaker two years ago.

Non-Ferrous Molding

William Boatright, 43, has 5-1/2 years experience in the foundry including 18 months in molding. Previously he worked in the grinding and melting departments.

Loring Thomas, 43, has seven years experience in the foundry including two years in molding. He has also worked in the grinding and finishing departments as well as melting and pouring.

Ralph Leland, 20, has three years foundry experience including one year in grinding and finishing departments and two years in molding.

Steel Molding

James Gift, Jr., 21, started with Dodge Steel Co. in 1955 in the chill department and became an apprentice molder in 1956. His father is also a molder with Dodge.

James Rogers, 21, majored in foundry courses in high school. He also participated in a foundry course given by the Oregon State Apprentice Council. In 1955 he started as an apprentice molder at Electric Steel Foundry Co.

Gordon Wambold, 22, became a graduate apprentice in March, 1958. He has taken related training at Waukesha Vocational School and the University of Wisconsin extension division.

Wood Patternmaking

Adam J. Kravetz started his apprenticeship program at Progress Pattern Co. in 1956 and is attending classes at Detroit Apprentice Training School in accordance with the program for apprentice training.

Gerald Celk, 23, attends East Los Angeles Junior College. He worked in the patternmaking departments of Aluminum Co. of America before beginning his apprenticeship program with John C. Buese Patterns.

Edward Lamparyk, 22, studied patternmaking in high school before beginning apprentice program with Modern Pattern Co. Under program he attends trade school one day weekly for three years and during final two years attends school one evening weekly.

Iron Molding

Raymond McDermott, 25, became a molding apprentice in 1951. After three years in the armed service he returned to continue his apprenticeship at Brown & Sharpe. He has been a journeyman molder for one month.

James Sanders, 26, started his apprenticeship at Fairbanks, Morse & Co. in 1954 following two years in the armed service. He has maintained an "A" average in related instruction given foundry apprentices at Beloit Vocational & Adult School.

Leslie Lowe, 22, started his 4-year apprentice course at Caterpillar in 1955.

National News

Annual Foundry Instructors Seminar Links Education and Casting Industry

■ Closer relations between secondary schools and the foundry industry and ways of fostering modern methods of foundry and pattern shop instruction will be among the topics discussed at the 3d Annual AFS Foundry Instructors Seminar.

The Seminar, sponsored by the AFS Education Division, will be held June 19-21 at Case Institute of Technology, Cleveland. The Society will assume

C. H. Pomeroy, speaker

all Seminar expenses in Cleveland. Chapters are assisting in transportation.

Among the topics to be discussed will be teaching aids, discussion of curicula, shop layout, laboratory facilities, casting methods, techniques and applications, in-plant training and career opportunities.

THURSDAY, JUNE 19

Morning Session

9:00-10:00 am—Registration, main lobby, Tomlinson Hall.
10:00-10:15 am—Welcome and orientation.
Co-Chairmen B. L. Bevis, Caterpillar Tractor Co., Peoria, Ill.; C. E. Nelson, Dow Chemical Co., Midland, Mich.
10:15–11:30 am—*New Casting Developments,* Prof. J. F. Wallace, Case Institute of Technology.

Afternoon Session

12:30-3:30 pm—Field trip, Aluminum Co. of America.
3:30-4:00 pm—Discussion of field trip.
4:00-4:45 pm—*Education and Our Industry's Survival,* film, I. H. Dennen, Beardsley & Piper Div., Pettibone Mulliken Corp., Chicago.
4:45-5:15 pm—*AFS Training & Research Institute,* R. E. Betterley, T&RI Training Supervisor.
6:00-7:00 pm—Dinner.
7:00-7:15 pm—Workshop orientation, R. E. Betterley.
7:15-9:30 pm—Workshops by selected groups.

FRIDAY, JUNE 20

Morning Sessions

9:00-10:30 am—Chairman C. E. Nelson. Workshop reports.
11:00-11:45 pm—*Safety in the School Shop,* H. J. Weber, AFS Director of Safety, Hygiene & Air Pollution Program.
12:00-1:00 pm—Lunch.

Afternoon Sessions

1:00-1:30 pm—Discussion of AFS Activities.
1:30-2:45 pm—Panel discussion of AFS.
1:30-2:45 pm—*AFS & Education,* a panel discussion.
3:00-4:00 pm—*Casting Quality,* Clyde A. Sanders, American Colloid Co., Skokie, Ill.
4:00-5:00 pm—*Crucible Melting and Care,* film, Crucible Manufacturers' Association.
6:00-8:00 pm—Dinner, Tudor Arms Hotel. Speaker, Cleve H. Pomeroy, National Malleable & Steel Castings Co., Cleveland.

SATURDAY, JUNE 21

9:00-10:00 am—*Cast Metals in Industrial Arts and Vocational Education Instruction,* Dewey Barich, Detroit Institute of Technology, Detroit.
10:15-11:15 am—*Technical Training for Tomorrow,* John P. Walsh, U.S. Office of Education, Washington, D.C.
11:15-12:00 Noon—Summary.
12:00-1:00 pm—Luncheon.
1:00-2:00 pm—Evaluation meeting.

T&RI Course Outlines Copper-Base Melting

■ *Melting of Copper-Base Alloys*, the first Training & Research Institute course dealing with non-ferrous metals was attended by 24 students April 2-4 in Chicago.

Three authorities in the non-ferrous field donated their time as instructors. They were: Harry Ahl, Samuel Greenfield, Inc., Buffalo, N. Y.; Herman L. Smith, Federated Metals Div., American Smelting & Refining Co., Whiting, Ind.; and R. L. Riddell, H. Kramer & Co., Chicago.

Subjects consisted of four major classifications: Classification of Alloys and Definition, Melting Equipment, Control of Melt Quality and Test Procedures for Quality Control.

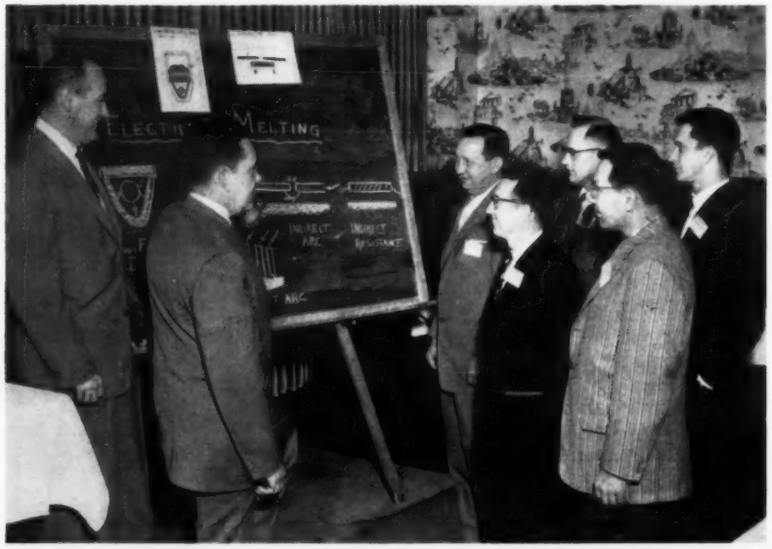
Classification of Alloys and Definition included information on scope and basis of classifications.

Among subjects discussed under Melting Equipment were electric and fuel-fired furnaces including applications, advantages, capacity and investment cost.

Control of Melt Quality included a discussion of furnaces, raw materials, effect of refractories, furnace atmosphere, fluxes and the temperature control.

Test Procedures for Quality Control covered its importance, fracture tests, specific gravity, fluidity, deep-etch testing and pressure testing.

Question and answer periods were held during the course and a 70-question achievement test was given all enrollees by R. E. Betterley, T&RI Training Supervisor.



Melting of Copper-Base Alloys instructors, Fred Riddell and Harry Ahl shown with students, left to right, Arthur E. Puschman, Essex Brass Corp., Detroit, Mich.; W. A. Wallace, Southern States Equipment Corp., Hampton, Ga.; Glen Futrell, Viking Pump Co., Cedar Falls, Iowa; Anthony Waller, Winters Foundry & Machine Co., Canton, Ohio and Robert E. Schuchardt, Carl Bajohr, Co., St. Louis.

Portion of students attending 3-day course on Melting of Copper-Base Alloys course held in Chicago.

1958 T&RI Courses

Sand Testing — **June 2-6—Detroit**

Demonstration and laboratory course. Basic testing methods and equipment are demonstrated in view of sand properties, variables and controls. Limited to 25. Registration fee $125.

Cupola Melting of Iron — **July 7-11—Chicago**

Lecture course for cupola operators, supervisors, metallurgists and foremen. Basic principles for optimum cupola operation are considered. Registration fee $65.

Sand Control Technology* — **Aug. 11-15—Detroit**

Lecture course for foundrymen having had some experience in sand testing control and technology. Pre-requisite; Sand Testing course or equivalent experience. Registration fee $65.

Patternmaking — **Aug. 18-20—Chicago**

Lecture and demonstration. Course for patternmakers, foremen, supervisors, trainees, purchasers of castings, suppliers and management. Registration fee $40.

Industrial Environment — **Sept. 8-12—Chicago**

Demonstration and lecture course on in-plant environmental problems and safety. Appropriate for foremen, supervisors, engineers, safety men and top management. Registration fee $65.

Metallography of Non-Ferrous Metals* — **Sept. 15-17—Chicago**

Lecture course for melters, supervisors, foremen, foundry engineers, researchers, laboratory technicians, metallurgists and design engineers. Registration fee $40.

Product Development — **Sept. 24-26—Chicago**

Lecture course on product analysis from design to marketing of finished castings. Scheduled for foundry engineers, sales engineers, technicians, supervisors, metallurgists and management. Registration fee $40.

Air Pollution Control & Legislation — **Oct. 1-3—Chicago**

Lecture course covering the laws and interpretation, problems, suggested solutions and the drafting of ordinances from the foundry standpoint. Registration fee $40.

Industrial Engineering — **Oct. 13-17—Milwaukee**

Lecture and work shop course on better standards and cost control. Rating and motions and time study techniques. Registration fee $125.

Gating & Risering of Ferrous Castings — **Oct. 27-31—Chicago**

Lecture course on the problems relating to gating and risering. Intended for foremen, technicians, foundry engineers, supervisors, industrial engineers and production and quality control personnel. Fee $65.

Foundry Plant Layout — **Nov. 10-12—Chicago**

Lecture course on problems of rehabilitation or building of new plants. Intended for foremen, supervisors, industrial and production engineers and management. Registration fee $40.

*Courses originally scheduled for other dates.

Payment of tuition fees should accompany enrollment application. Makes reservations only with Director, AFS Training & Research Institute, Golf & Wolf Roads, Des Plaines, Ill. Tel VAnderbilt 4-0181.

Chapter News

Schedule AFS Headquarters Tour for June Chapter Officers Conference

■ A visit to the National Office in Des Plaines, Ill., has been arranged for Chapter Chairmen and Program Chairmen attending the 15th Annual Chapter Officers Conference to be held June 12-13.

At the Central Office, Chapter Officers will be divided into several groups to meet with AFS Officers and Staff. The head of each staff department will outline activities and policies of his department. The meetings will be informal and questions will be invited. Each group will visit all of the staff departments.

A better understanding of the Society operations is expected to result from the group meetings based on the success of the workshops at the annual Foundry Instructors Seminar.

Additional meetings and the Conference Banquet will be held at the Hotel Sherman in Chicago. Dr. Dewey Annakin, Indiana State College, Terre Haute, Ind., will speak on *"Backdrop for Survival."*

Education Division Movie Now Underway

Production has started on a 16-mm, sound educational movie showing the importance, use and manufacture of castings and the training of qualified personnel for the foundry industry.

The 25-min color movie with narration features a broad coverage of uses of castings in home and industry. It is suited for showing to students as well as technical and non-technical groups.

Originally the film was produced by Beardsley & Piper as a silent movie entitled *Education and Our Industry's Survival*. Beardsley & Piper has underwritten the cost of the movie in silent form. Upon recommendation of the Program & Papers Committee of the Education Division the Society has authorized funds to add a sound track and the production of two copies.

The film was previewed by the Program & Papers Committee at its March meeting in Chicago and recommendations made at that time for use of the film with the addition of sound.

Cupola Group Starts Work on New Project

■ A program has been initiated by the Cupola Advisory Committee to develop information relating to hot-blast acid-lined cupola operation, using data that is available and to compare it with similar data developed from cold-blast operation.

The work is being undertaken by a sub-committee composed of W. R. Jaeschke, H. H. Wilder and W. W. Levi. Factual data is being solicited from foundries in the United States employing these cupolas.

Tuyere design and blast penetration was selected for possible future research program.

Committee members conducted their March meeting at the LeClaire Hotel in Moline, Ill., and after the meeting inspected the water-cooled cupolas and water-cooled tuyere installations at Deere & Co.

Core Test Group to Make Book Revisions

■ Daniel R. Chester, Archer-Daniels-Midland Co., Cleveland was elected chairman of the Sand Division Core Test Committee at its March meeting in Cleveland. Donald S. Mills, General Motors Corp., Detroit, was elected Vice-Chairman.

The committee took action to make revisions in the FOUNDRY SAND HANDBOOK dealing with the tentative testing procedure of the CO_2 process for making cores.

Investigation will also be made into the possibility of devising a tentative standard test method for the self-curing binders.

Radiation Protection Manual Group Reports

■ Progress on the RADIATION PROTECTION MANUAL was discussed at the March meeting of the Radiation Protection Committee held in Chicago.

The manual will be composed of nine sections including an Introduction, Nature & Sources of Radiation in the Foundry, Health Aspects of Radiation, Control of Radiation in the Foundry, Radiation Detection, Protection by Shielding & Distance, Procedure for Handling and Use of Sources of Radiation, Training of Personnel and Glossary.

Assignments were made to committee members. Portions of the text have been written and approved by the Radiation and Steering Committees.

Philadelphia Chapter

Holds Casting Clinic

■ More than 140 foundrymen attended the April meeting to participate in a round table discussion on new developments in cast metals.

Apprentice awards were also made at the meeting. AFS Regional Vice-President O. J. Myers, Reichhold Chemicals, Inc., White Plains, N.Y. attended the meeting.

Participating in the round table discussion were:

Eugene Lanar, Dodge Steel Co., Philadelphia.

John Juppenlatz, Quaker Alloy Castings, Myerstown, Pa.

H. Reitinger, consultant, Beverly, N.J.

James Vanick, International Nickel Co., New York.

Joseph Allen, Jr., American Smelting & Refining Co., Newark, N.J.

R. B. Fischer, Ingersoll-Rand Co., Phillipsburg, N. J.—*E. C. Klank*

AFS Regional Vice-President O. J. Myers (left) and **Philadelphia** Chapter Chairman H. C. Winte.

Participating in **Philadelphia's** April round table discussion were Eugene Lanar and John Juppenlatz representing steel. H. Reitinger and James S. Vanick representing cast iron. Joseph D. Allen Jr., and R. B. Fischer representing non-ferrous. — *Leo Houser*

Philadelphia Education Chairman E. X. Enderlein, H. G. Enderlein Co., Philadelphia (right) presents apprentice awards. Winners are William Phillips, Olney Foundry, Philadelphia; Fred Rothenhofer, Dodge Steel Co., Philadelphia; Peter Capritti and John Filippine, both of Florence Pipe Foundry & Machine Co., Florence, N.J.

St. Louis District Chapter Honors Apprentices

■ The March meeting featured a talk by A. F. Pfeiffer, Allis-Chalmers Mfg. Co., Milwaukee, on *"Coordinative Function of Pattern Equipment and Castings."*

AFS Field Director Dan J. Hayes also addressed the meeting on problems dealing with AFS membership. *–H. V. Boemer*

Dan J. Hayes, AFS Field Director on left, and A. F. Pfeiffer, were speakers at the St. Louis March meeting. Chapter Chairman James Cannon, Duncan Foundry & Machine Works, Alton, Ill., is on right.

Old-timers meet again at **St. Louis Chapter** meeting in March. William Buckner, shown on left, was foundry superintendent and worked with A. F. Pfeiffer, right, at the Milwaukee plant from 1938-1944. Buckner is now president of Buckner Foundry Co., East Alton, Ill. Pfeiffer, speaker at the March meeting, has been employed by Allis-Chalmers for 55 years. He is a past president of the Wisconsin Chapter.

Apprentice Certificates and handbooks were awarded to apprentices by Dale Arnette, Arnette Pattern Co. Left to right are Mathew Bertz, Belleville Pattern Co.; Lody Milkovich, American Steel Foundries, Inc.; Milfred Shadwick, General Steel Castings Corp.; Charles Benda, Central Pattern Co.; Joe Wilson, Central Pattern Co., Dale Arnette.

Awards were presented to apprentice winners in wood and metal patternmaking at the St. Louis March meeting. Left to right are S. R. Strayhorn, Progressive Pattern Co.; Don Mason, Reimler Pattern Co.; Donald Kuenzel, Central Pattern Co.; Milfred Shadwick, General Steel Castings Corp.; Elbert Williams, Central Pattern Co.; Apprentice Contest Chairman Ralph Petersen, Central Pattern Co.; Arthur Wildermuth, American Steel Foundries, Inc.; Joe Wilson, Central Pattern Co.; Walter Kaetzel, Central Pattern Co.; Paul Neibur, Central Pattern Co.; Ron Heckel, Progressive Pattern Co.

Central Ohio

Honors Apprentice Winners

■ Winners of the chapter's apprentice contest were announced at the April meeting. Two speakers were also featured. W. C. Webb, Bureau of Apprenticeship, U. S. Dept. of Labor, spoke on *Education* and J. E. Haller, James B. Clow & Sons, Inc., Coshocton, Ohio, discussed *Metal Penetration in Sand.*

Webb reported to the chapter on progress in the foundry industry, a survey on jobs in foundries, and apprentice training based on his contacts with 400 foundries in Ohio, Michigan and Kentucky.

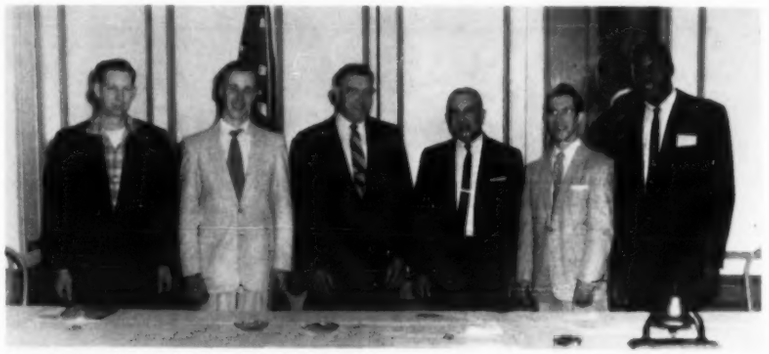
Haller, a member of the Mold Surface Committee of the AFS Sand Division, reviewed the work of that group.

Apprentice winners were:

Gray Iron Molding–George Davis, Burnham Corp.; Charles Jewell, Burnham Corp.; and Robert Higgins, Cooper-Bessemer Corp.

Steel Molding–Homer Leeth, Ohio Steel Foundry and Willie Gaines, Ohio Steel Foundry.

Wood Patternmaking–Arlen Munsey, Ohio Steel Foundry and Darrel Sickles, Ohio Steel Foundry.–*Jose Acebo*



Central Ohio Chapter's April meeting was devoted to apprentices and education. Left to right are George Davis, Burnham Corp., 1st place winner in gray iron molding; Charles Jewell, Burnham Corp., 2d place winner in gray iron molding; speaker W. C. Webb, Bureau of Apprenticeship, U.S. Dept. of Labor; speaker J. E. Heller, James B. Clow & Sons, Inc., Coshocton, Ohio; Robert Higgins, Cooper-Bessemer Corp., 3d place winner in gray iron molding; Willie Gaines, Ohio Steel Foundry, 2d place winner in wood patternmaking.

John Wilson, Climax Molybdenum Co., Los Angeles (center) was the featured speaker at the April meeting of the **Washington Chapter.** Others are Chapter Treasurer Jack Uren, Firebrick Supply Co., Seattle, Wash.; retiring Chapter Chairman William K. Gibb, Atlas Foundry & Machine Co., Tacoma, Wash.; Chapter Chairman Leon Morel, Morel Foundry Corp., Seattle, Wash.; Chapter Secretary Frank Jefferson, Frank Jefferson, Inc., Seattle, Wash.–***Frank H. Jefferson***

Washington Chapter

Elects New Officers

■ Officers and Directors for the 1958-1959 season have been elected by the Washington Chapter.

Chairman–Leon Morel, Jr., Morel Foundry Corp., Seattle, Wash.

Vice-Chairman–Vernon W. Rowe, Balard Pattern & Brass Foundry, Seattle, Wash.

Treasurer–John W. Uren, Firebrick Supply Co., Seattle, Wash.

Secretary–Frank H. Jefferson, Frank H. Jefferson, Inc., Seattle, Wash.

Directors (Terms expire 1961)–Herbert Rushfeldt, Atlas Foundry & Machine Co., Tacoma, Wash.; Thomas O'Brube, Materials Reclamation Co., Seattle, Wash.; Everett Behrmann, Olympic Foundry, Auburn, Wash.

Saginaw Valley Chapter held its Ladies Night program at the Bancroft Hotel, Saginaw, Mich. More than 250 persons attended the annual event which includes dinner and dancing.—*R. J. Gleffe*

Six past presidents of the **Saginaw Valley Chapter** attended the April meeting. Left to right are James E. Bowen, Chevrolet Saginaw Grey Iron Foundry, Saginaw, Mich.; Kenneth Priestely, Vassar Electroloy Products, Inc., Vassar, Mich.; Woodrow Holden, Dostal Foundry & Machine Co., Pontiac, Mich.; Chapter Chairman Vernon J. Sadler, General Foundry & Mfg. Co., Flint, Mich.; Fred P. Strieter, Dow Chemical Co., Midland, Mich.; Marshall V. Chamberlain, Dow Chemical Co., Midland, Mich.; Oscar E. Sundstedt, General Foundry & Mfg. Co., Flint, Mich. — *R. J. Gleffe*

Saginaw Valley members at the April meeting heard Hugh A. Wichert, personnel and business consultant, speak on *Humanics*.

Twin City Chapter

Synthetic Sand Practice

■ Synthetic sand practice was outlined at the April meeting by Victor Rowell, Harry W. Dietert Co., Detroit. He emphasized that castings must be metallurgically sound as well as accurate and attractive in appearance to compete in today's market.

He recommended the use of a reasonably fine grained sand with sufficient clay for good green, dry and elevated temperature properties, low moisture, and ramming the molds hard. Water should be added to green sand primarily to pasticize and activate the clay. The degree of pasticity should be more in the nature of a moist powder rather than a heavy mud.

Improved flowability and reduction in mold wall movement tendencies can be achieved in this manner. A gain in finish and tolerance can be made simply by keeping the moisture as low as it can be worked.

Allowances will have to be made for the equipment and rigging involved but the lower practical level of moisture is the most desirable in all cases, he stated.

In summary he said that synthetic sand practice using established methods of green and high temperature control can furnish the means for producing superior castings.—*J. David Johnson*

Northern California

Patternmaking Clinic

■ Three local patternmaking men conducted a patternmaking clinic at the April meeting. Mark Thomas, Pacific Pressure-Cast Products, Richmond, Calif., discussed the plaster-cast method of producing patterns and the use of matchplates.

George Wettstein, Oakland Pattern Works, exhibited several plastic duplications of patterns which required slight modification or had to be duplicated to facilitate production. Wettstein explained that plastic patterns could be made at lower cost than by conventional methods.

Angelo Castagnola, A.B.C. Pattern Works, Oakland, Calif., explained problems involved in the production of patterns for shell casting, dealing with the methods, materials, and tolerances necessary for the best results.—*Harold Henderson*

New England Chapter

Hears Russian Trip

■ The April meeting was held at the Metals Process Laboratory, Massachusetts Institute of Technology, Cambridge, Mass. Prof. Morris Cohen, department of metallurgy, spoke on his recent trip to Russia emphasizing Soviet education in metallurgy and progress which Russia has made.—*F. S. Holway*

Northwestern Pennsylvania

Water-Cooled Cupolas

■ Sixty-five members and guests attended the March meeting to hear M. H. Horton, Deere & Co., Moline, Ill., discusses *Water-Cooled Cupolas, Construction, Economics, Operation and Problems.*

The chapter has instituted a new system of identification for its members. Instead of the usual pocket inserts, members are given a permanent lapel identification with the individual's name and company affiliation. Membership Chairman Mrs. O. C. Bueg, Arrow Pattern & Engineering Co., Erie, Pa., has charge of issuing and maintaining the badges.—*Walter Napp*

Oregon Chapter members at the April meeting heard John E. Wilson, Climax Molybdenum Co., discuss *Some Factors Affecting the Behavior of Steel Castings.* — *Bill Walkins*

Oregon Students Elect Officers

■ Officers for the 1958-59 season have been elected by the Oregon Student Chapter. Officers are:

Chairman—Charles F. Query.
Vice-Chairman—Sil L. Arata.
Secretary—Dee J. Hillberry.
Treasurer—Donald Dauterman.

M. H. Horton, March speaker at the **Northwestern Pennsylvania** Chapter.

Northwestern Pennsylvania members are issued permanent lapel identification. On left is Chapter Membership Chairman Mrs. O. C. Bueg, on right is official greeter R. N. Wheatley, Eastern Clay Products Co.

A Review of the Use of Reinforced Plastics was presented at the April meeting of the **Eastern Canada Chapter** by H. Burron, Canadian Steel Foundries (1956) Ltd., Montreal, Que. Left to right are Director S. G. Singleton, Legare Foundry, Ltd., Sherbrooke, Que.; Director M. Trottier, Quebec Iron & Titanium Corp., Sorel, Que.; Secretary L. Myrand, Montreal Foundry, Ltd., Montreal, Que.; Director J. H. Roberts, Canada Iron Foundries, Ltd., Troi-Rivieres, Que.; Vice-Chairman M. Reading, Foundry Services (Canada), Ltd., Montreal, Que. speaker Burton, Wm. C. H. Dunn, Western Pattern Works, Montreal, Que.; Director W. Tibbits, Canadian Steel Foundries (1956), Ltd.; Treasurer T. Niven, Canadian Steel Foundries (1956), Ltd., Montreal, Que.; and W. Nutall, Warden King, Ltd., Montreal, Que. — *F. Machin*

Four members attending the March meeting of the **Northwestern Pennsylvania Chapter** are L. Davis, Erie Forge & Steel Co.; W. J. Miller, Frederic B. Stevens, Inc., and C. Wagner and A. Lesniewski, Erie Forge & Steel Co.

U.S. Senator Karl Mundt, South Dakota, was featured speaker at the April meeting of the **Wisconsin Chapter.** Shown left to right at the Management Night meeting are T. H. Tanner, Zenith Foundry Co., Milwaukee; speaker Mundt; and AFS Director A. M. Slichter, Pelton Steel Casting Co., Milwaukee. — *Bob De Broux*

Washington Chapter

Steel Castings Talk

■ *Some Factors Affecting the Behavior of Steel Castings* was presented at the April meeting by John E. Wilson, Climax Molybdeum Co., Los Angeles.

Among the topics covered were melting and casting practice, heat treatment and hardenability, and wear resistance. — *Frank H. Jefferson*

British Columbia

Steel Castings Talk

■ April's meeting featured a talk on Some Factors Affecting the Behavior of Steel Castings by John E. Wilson, Climax Molybdenum Co., Los Angeles. The importance of hydrogen distribution when correlating hardness and cooling, along with the transformation determinations of chemical composition were discussed in detail. — *J. T. Hornby*

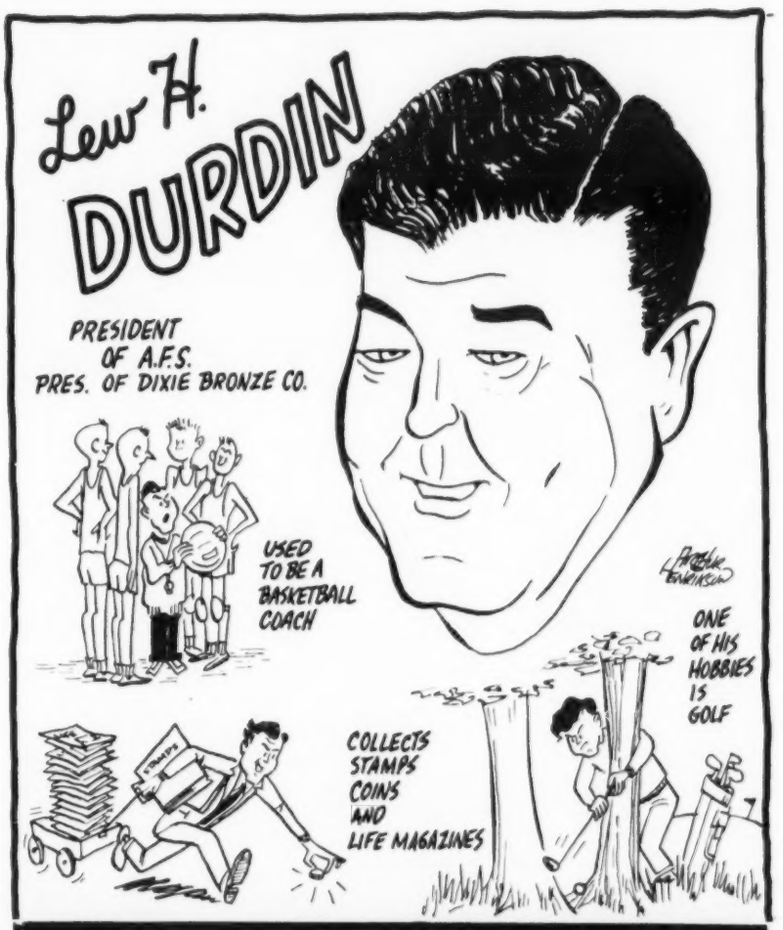
Leon Kimpal with mementos presented by the **Rochester Chapter.** Education Chairman Duncan M. Wilson, Engineered Castings Div., American Brake Shoe Co., Rochester, is on right.

Central New York

Meeting the Challenge

■ *The Recession and Unemployment Problems* were discussed in March by Rev. Richard M. McKeon, S. J., LeMoyne College, in a meeting held at LeMoyne Manor, Liverpool, N.Y.

Father McKeon said that American business must expand in times rising unemployment and must expand facilities, improve products and increasing advertising. Factors causing the present economic condition and factors which would lead to an upturn were also discussed. — *C. W. Diehl*



Personalities

Thanks Received for Phillipine Team Tour

■ A recently completed tour of the United States by a Phillipines foundry and machine shop productivity team was highly successful, according to Leslie A. White, project manager, International Cooperation Administration, Washington, D. C.

In a letter to the Society Headquarters, White expressed his appreciation to the foundry industry on behalf of the International Cooperation Administration.

Said White, "On the basis of optimistic comments by all members of the team at the close of the project, we feel that it will prove to be one of the most successful and worthwhile undertakings of its kind during recent years."

Tri-State Chapter

Castings Round Table

■ Seven speakers discussed *Metal Castings in Modern Industry* at the April meeting. Panelists represented design, engineering, pattern, castings, machine shop, production, and purchasing.

Participating were:

R. W. Trimble, AFS Regional Vice-President, Bethlehem Supply Co., Tulsa, Okla.

Clint Cross, W. C. Norris, W. C. Norris Mfg. Co., Tulsa, Okla.

J. H. Jensen, Manning, Maxwell & Moore Co., Tulsa, Okla.

George Camp, Frank Wheatley Pump & Valve Mfg. Co., Tulsa, Okla.

M. C. Hellander, Empire Pattern & Foundry Co., Tulsa, Okla.

Dan Mitchell, Progressive Brass Mfg. Co., Tulsa, Okla.

Jules Henry, Missouri Steel Castings Co., Joplin, Mo. — *Leslie A. O'Brien*

afs chapter meetings

JUNE

Central Illinois . . June 14 . . *Annual Clambake–Barbecue Stag.*

Central Michigan . . June 7 . . Coldwater Country Club, Coldwater, Mich. . . *Annual Outing.*

Chesapeake . . June 5 . . American Radiator & Standard Sanitary Corp., Arlington Bronze & Aluminum Corp., and Franklin Balmar Corp. *Plant Visitation.*

Connecticut . . June 20 . . Restland Farms, Northford, Conn. . . *Annual Outing.*

Detroit . . June 28 . . Glen Oaks Country Club . . *Golf Outing.*

Eastern New York . . June 21 . . Willow Brook Inn, Schenectady, N. Y. . . *Annual Outing.*

New England . . June 13 . . Blue Hill Country Club . . *Annual Outing.*

Northeastern Ohio . . June 21 . . Twin Lakes Country Club, Twinsburg, Ohio . . *Golf Outing.*

Northwestern Pennsylvania . . June 2 . . Amity Inn, Erie, Pa. . . E. J. Mapes, Pickands Mather & Co., *"Taconite Ore" and Film, American Iron Frontier.*

Quad City . . June 16 . . *Annual Picnic.*

Saginaw Valley . . June 7 . . I.M.A. Lodge, Potter's Lake, East of Davison, Mich. . . *Annual Outing.*

Texas . . June 14 . . Fredonia Hotel, Nacogdoches, Texas. *Joint Meeting with East Texas Section.*

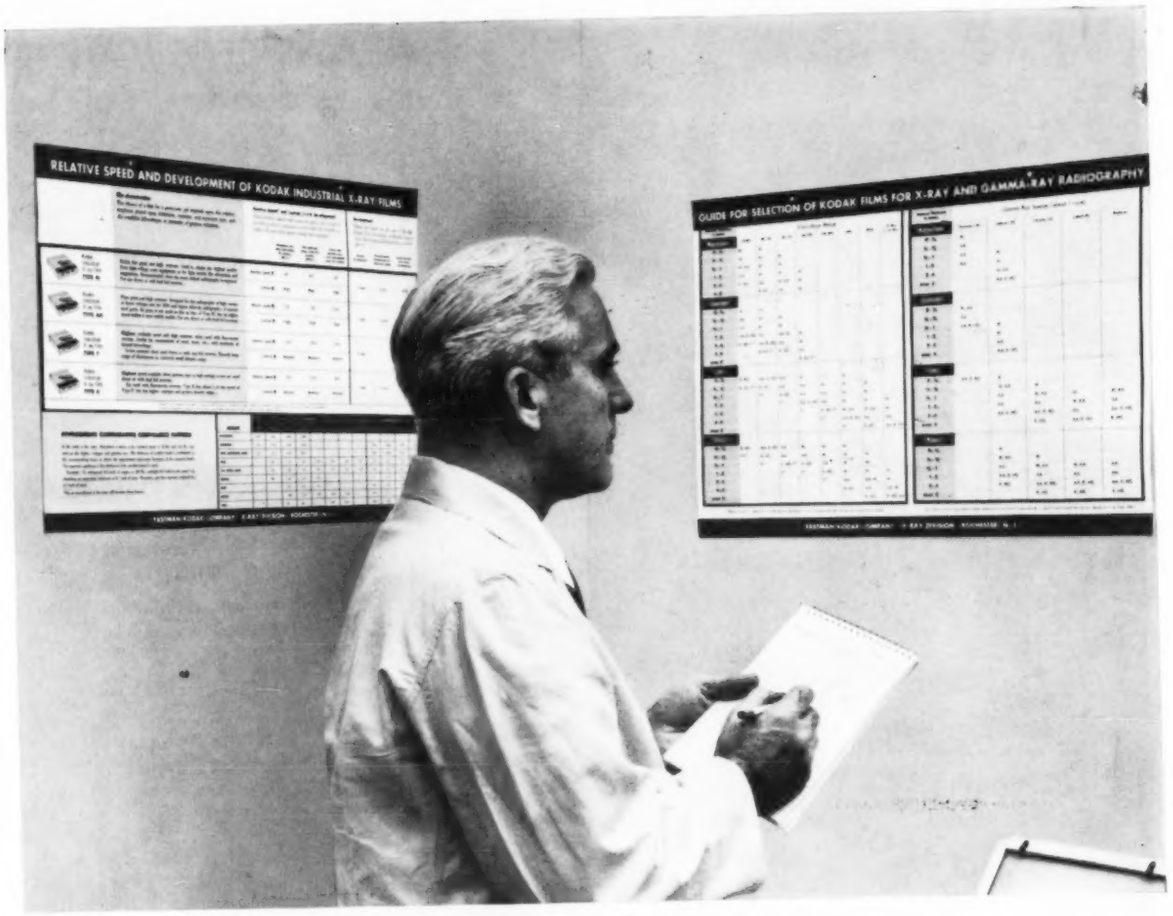
Tri-State . . June 21 . . Svithiod Lodge, on Rock River . . *Annual Picnic.*

Western New York . . June 14 . . Sturm's Grove . . *Annual Stag Outing.*

JULY

Wisconsin . . July 25 . . Tuckaway Country Club . . *Annual Outing.*

MORE FACTS on all products, literature, and services shown in the advertisements and listed in Products & Processes and in For the Asking can be obtained by using the handy Reader Service cards, pages 7-8.


RELATIVE SPEED AND DEVELOPMENT OF KODAK INDUSTRIAL X-RAY FILMS
GUIDE FOR SELECTION OF KODAK FILMS FOR X-RAY AND GAMMA-RAY RADIOGRAPHY

Important Radiographic data at a glance

Free Wall Charts give you latest information on film selection, relative speed, and contrast.

TODAY's fast films and varied radiation sources give the present-day radiographer many new opportunities for establishing exposure factors to meet unusual conditions and get better radiographs.

So that you can have the latest information right before you, Kodak has prepared two quick-reference wall charts—one, a guide for selecting the best type film for your x-ray and gamma ray work—the other, showing relative speed, contrast, and development of Kodak Industrial X-ray Films.

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X-ray Division, Rochester 4, N. Y

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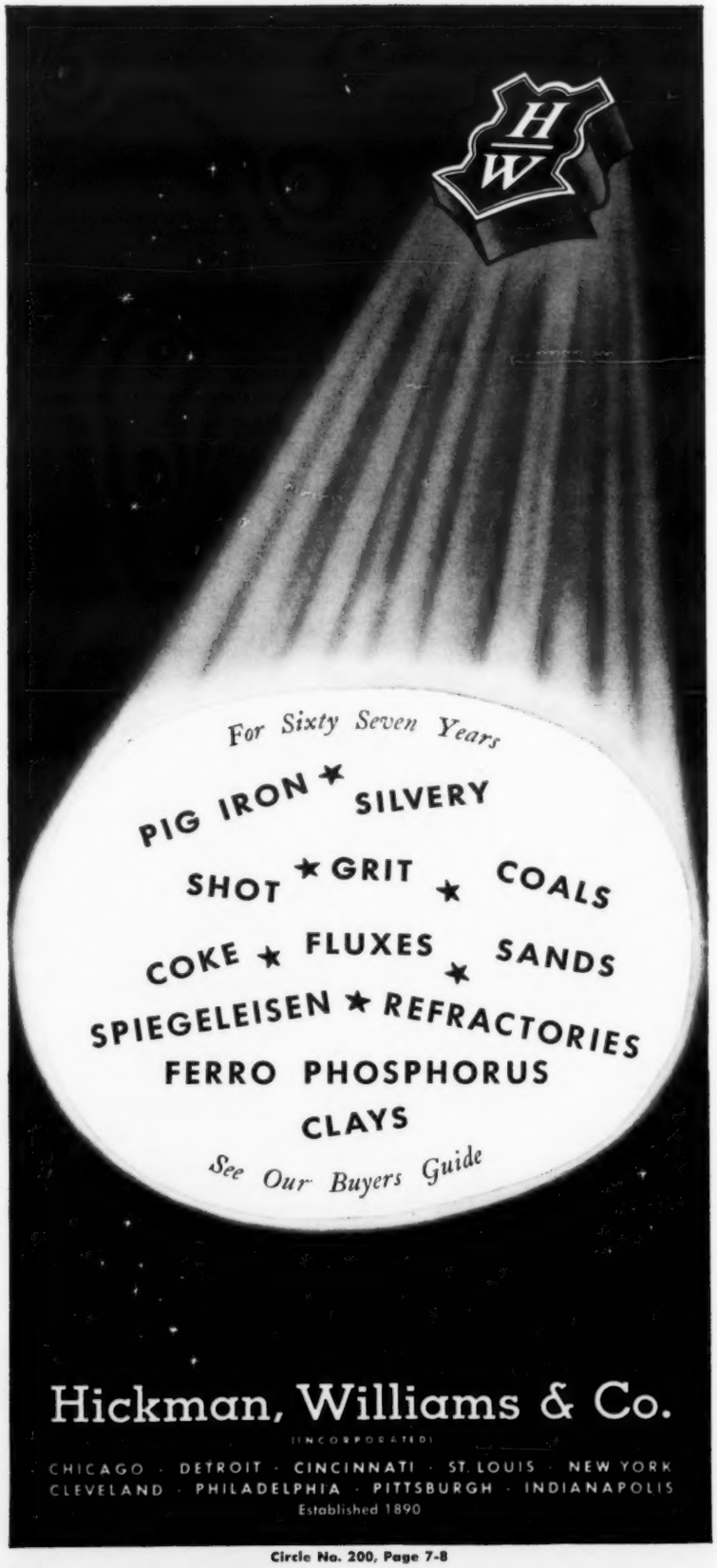
TRADE MARK

Circle No. 199, Page 7-8



Circle No. 200, Page 7-8

Campbell, Wyant and Cannon, Pioneer Foundry, Celebrates 50 Years of Growth

■ A half-century ago—in the spring of 1908—three young men with courage and vision invested $1000 each to launch a new business venture.

Today, Campbell, Wyant and Cannon Foundry Co., division of Textron Inc., the company they founded, is among the leaders in the nation's

1908 foundry

foundry industry—holding title as the largest independent gray iron foundry in the world.

Donald J. Campbell, Ira A. Wyant and George W. Cannon, the three working foundrymen who paid themselves $15 weekly in that first torturous year, founded their infant company in a tiny shop with an initial capacity of five tons of castings daily.

Today, CWC operates six plants, four in Muskegon, Mich., and one each at Lansing and South Haven. It normally employs upwards of 2500 workers. From a payroll which gradually swelled to $7500 in that first year, the firm now has a payroll which is exceeding 11 million dollars annually.

In observing its 50th birthday, CWC can look back with pride on many achievements, the following of which are perhaps the most noteworthy:

1) Castings of the world's first four-cylinder engine block.
2) Development of cast, out-of-round piston rings for today's engines.
3) Invention of the centrifused brake-drum utilizing fused iron alloy with steel—standard equipment on many cars today and U. S. bombers used in World War II.
4) First to develop the cast camshaft, a 1936 innovation which has saved motor makers millions of dollars yearly.
5) Pioneering use, in 1931, of the electric furnace to permit continuous pouring of molten metal with exact control.
6) Development of spectographic analysis, in collaboration with the University of Michigan, to provide vital information to foundrymen when they need it most—before the molten metal is poured.
7) First in the foundry industry to use million-volt x-ray to detect flaws in metal.

Soon after opening their foundry for business in 1908, an order from Continental Motors Corp. put them in the automotive field permanently. CWC grew rapidly on the subsequent business of producing gray iron castings for the automotive industry.

High quality production on the Continental order proved the springboard to success. Within a year, production rose from five tons daily to 12 tons and a backlog of orders had begun to accumulate. In another year 50 employees were on the books and the original plant measuring 80 x 50 ft was so crowded that a new building had to be purchased.

Within a decade, CWC's payroll passed the two million dollar mark and further expansion was a necessity. Acquiring an 80-acre tract on Henry Street, the firm erected in 1922 the nucleus of what is today the main plant. A modern office building, fronted by beautiful landscaped grounds, was added in 1929 with other improvements.

1958 foundry

Meanwhile, the corporate structure also was undergoing changes. CWC was re-incorporated in 1927 with net assets of 3-1/2 million dollars. This was astounding growth, considering the modest $3000 start barely 19 years earlier.

National Motors Casting Co. plant at South Haven was acquired in 1929. Still a subsidiary, the South Haven plant added 30,000 tons to CWC's annual production.

Erection of the Centrifugal Fusing Co. plant at Lansing came in 1936. Motor Wheel Corp., which had been shipping steel shrouds to Muskegon for fusing with iron braking surfaces,

put up the structure adjacent to its plant with CWC furnishing and installing equipment.

Campbell, then president, had developed the centrifuse process originally used on leading automobiles in 1931. Years later, the CWC-developed centrifused brake drums were used as components for B-29 aircraft and motorized military equipment.

While numerous plant improvements and smaller plant facilities were added during depression years, the next major expansion came in January, 1941. Plant No. Four, designed for production of cast crankshafts to be used principally in large diesel engines, was started. Completion came at an opportune time—February, 1942—shortly after the United States became engaged in World War II.

Although the two remaining members of the original partnership are no longer active, Campbell, Wyant and Cannon has continued its leadership in the foundry industry by maintaining the high standards set at the beginning.

In 1956, when control of CWC was acquired by Textron Inc., the foundry that started with $3000 had become a 15 million dollar business.

Proper Gating Procedures Improve Castings Quality

by J. F. WALLACE
Case Institute of Technology
Cleveland

■ Properly engineered gating procedures can greatly improve the quality of gray iron castings. The first requirement is to establish a pouring time for the optimum quality of each casting based on a consideration of 1) the fluidity of the iron (superheat and composition), 2) average or predominant thickness of the casting and 3) weight of the casting.

Secondly, a properly designed gating system will 1) provide the selected pouring time and 2) permit the molten iron to enter the mold cavity without agitation, erosion, drossing or aspiration of gas into the metal.

Investigators have developed horizontal gating systems which minimize metal and mold damage. Components of these systems include: a pouring basin, a tapered sprue choked at the bottom, a sprue well, large runners and (for ferrous metals) large ingates in the drag.

This system has been adapted to gray iron permitting control of dimensions to assure the designed pouring rate.

■ Presented at the 1958 Wisconsin Regional Foundry Conference.

Heavy Equipment Foundry Reports:

FASTER SET-UP
EASIER SHAKEOUT
of cores made with **RCI COROVIT BINDER**

Big cores, like the one you see here, are commonplace at the Kennedy-Van Saun Manufacturing & Engineering Corp. in Danville, Penn. "With RCI COROVIT 7202 binder", says Mr. Harry Lynn, assistant foundry manager, "*cores that required up to 36 man-hours to produce are now finished in 12!*

"No more hand ramming is needed," Mr. Lynn explained. "COROVIT sand is simply shovelled into the box, spread out by hand, then struck off.

"In addition, COROVIT-based sand mixed with RCI's accelerator cures partially at room temperature. It hardens quickly to support itself, thereby *eliminating up to 75% of arboring, wiring, etc.*

"Another big advantage in using Reichhold COROVIT is easy shakeout every time.

"At Kennedy-Van Saun", Mr. Lynn concluded, "we plan to convert almost completely to this core binder, which gives us *the most efficient, fastest method of preparing cores that we have found to date.*"

If *you* would like full information on using this important new *self-curing* core binder, write to RCI for COROVIT BULLETIN F-11-R.

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FOUNDREZ—Synthetic Resin Binders
COROVIT—Self-curing Binders
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Circle No. 201, Page 7-8

Report on Casting Technology for Tomorrow

Continued from page 37

Malleable Iron

■ Here are the important conclusions disclosed in technical papers presented at the 62d AFS Castings Congress. These summaries cover talks relating to Malleable Iron, Patternmaking, Steel, Fundamental Papers, Management Development and Plant & Plant Equipment. The July issue of MODERN CASTINGS will complete this Report on Technology with abstracts of remaining papers presented in Cleveland and not covered here.

Observations on Pinhole Defects in White Iron Castings, R. W. Heine, Department of Mining and Metallurgy, University of Wisconsin, Madison.

Heine concluded that major cause of pinhole defects in white iron castings is slag formation during cooling of molten metal. Such pinholes are readily identifiable by characteristic mode of occurrence and are type most readily promoted by variable conditions of gating, pouring, sand and molding practices of foundries. Aspiration, evolution and isolated pinholes are less likely to occur; characteristics also make them readily identifiable.

Malleable Iron Microstructures Effect and Cause, report of AFS Malleable Division Controlled Annealing Committee.

The purpose of the paper is to set forth the basic microstructures commonly found in malleable iron metallurgy as well as some of the abnormal structures arising from known causes. The report included a collection of photomicrographs intended as guides representative of good normal practice. Metallurgical defects which may develop when processing goes out of metallurgical control were included. Characteristic edge structures and core structures of ferritic malleable iron were shown, and their variations explained.

Salt Bath Heat Treatment vs Quench and Temper: Standard and Pearlitic Malleable, P. W. Green, Erie Foundries, General Electric Co., Erie, Pa.

This paper includes 1) coverage of the basic manufacturing methods of standard and pearlitic malleable iron production; 2) physical property comparison between oil-quench and temper and isothermal salt transformation of standard and pearlitic malleable iron and 3) comparison of microstructures, mechanical properties and hardness values obtained from the two heat treating techniques.

Green concludes that:

1) in the oil quench and temper technique, high manganese pealitic materials have higher tensile and yield values than regular malleables for a given tempering temperature.

2) For the same hardness values regular and pearlitic materials develop the same elongation and relatively the same tensile and yield.

3) The higher the tempering temperature the softer the product in a straight line function.

4) With salt bath treating, the acicular transformation products have higher tensile, yield and elongation properties than the pearlitic transformation products for comparable hardness levels.

5) Comparing equal hardness values, the acicular transformation products have higher ductilities than the oil-quenched and tempered materials.

Annealing of Malleable Iron: Effect of Repeated Annealing on Rate of Second Stage Graphitization, J. E. Rehder, Canada Iron Foundries, Ltd., Montreal, Que. and J. E. Wilson, Canada Iron Foundries, Ltd., Toronto, Ont.

An examination is made of the process of elimination of pearlite in the annealing of black heart malleable iron. The study shows that repetition of the process results in increased annealability or ease of elimination of pearlite.

Pearlite elimination is affected strongly by the thermal history of the material. The effect is towards greater annealability, and amounts to as much as 85 per cent on the first repeat. This effect is apparently independent of soaking time at high temperature. Hardness decreases as annealing is repeated. The mechanism or cause of the effect is not known.

Steel Scrap Specifications for Duplexing Cupola White Iron, R. H. Greenlee, Auto-Specialties Mfg. Co., St. Joseph, Mich.

Greenlee presents known facts concerning costs and metal quality which result from the use of improper steel melting scrap. He describes a program instituted at his company said to prove the necessity of requiring rigid specifications for the purchase of steel melting scrap for cupola-electric-duplexing of malleable iron.

Incoming cars of scrap are checked carefully for alloy contamination, quality of bundles, cleanliness of the car, etc. Accepted cars which, during unloading, are found to not meet specifications are rejected.

Greenlee concludes as follows:

1) Melting costs can be reduced

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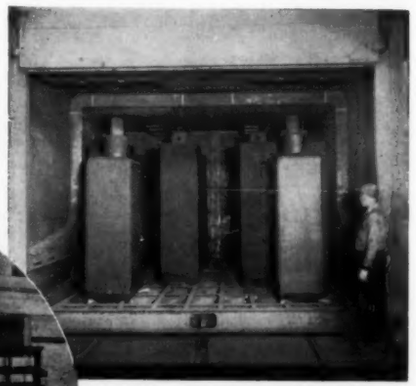

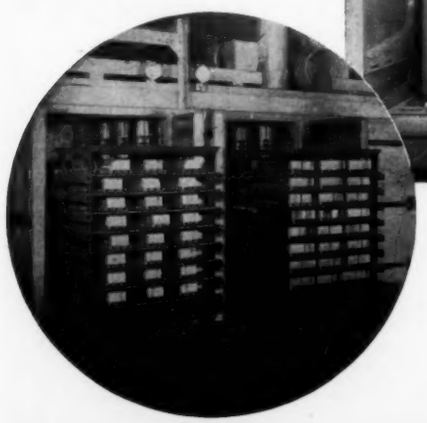

(above) Car type mold drying oven installed at Centre Foundry, Wheeling, West Virginia.

(left) Rack type Recirculating Gas-Oil Fired Core Ovens at Golden Foundry, Columbus, Indiana.

Write for Bulletin 53-CM

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in any foundry by instituting quality specifications on all incoming melting scrap.

2) Less casting scrap will be produced due to chemical analysis, particularly from high residual alloys contained in iron alloys which originated from purchased scrap.

3) Annealing costs will be reduced as a result of shorter annealing cycles.

Hardenability of Pearlitic Malleable Iron, report of AFS Pearlitic Malleable Committee (6E).

This report was prepared as a presentation of end-quench hardenability curve data. Six foundries submitted castings for Jominy end-quench hardenability tests, from which the following conclusions were reached:

1) Similar hardenability curves are produced regardless of whether liquid or air quenching is employed prior to pearlitic malleable heat treatment.

2) Austenitizing at 1600 F raises the hardenability curve slightly compared with austenitizing at 1500 F.

3) Hardenability curves of irons from foundries producing metal of similar chemical analysis fall in a remarkably narrow band.

4) A lower hardenability curve was obtained for iron having a low percentage of manganese and silicon.

5) A higher hardenability curve was obtained for an iron specially alloyed with manganese.

Pearlitic malleables of higher hardenability could be produced through alloying as practiced in steels. The engineer may use the curves for estimating the response to quenching in water or oil.

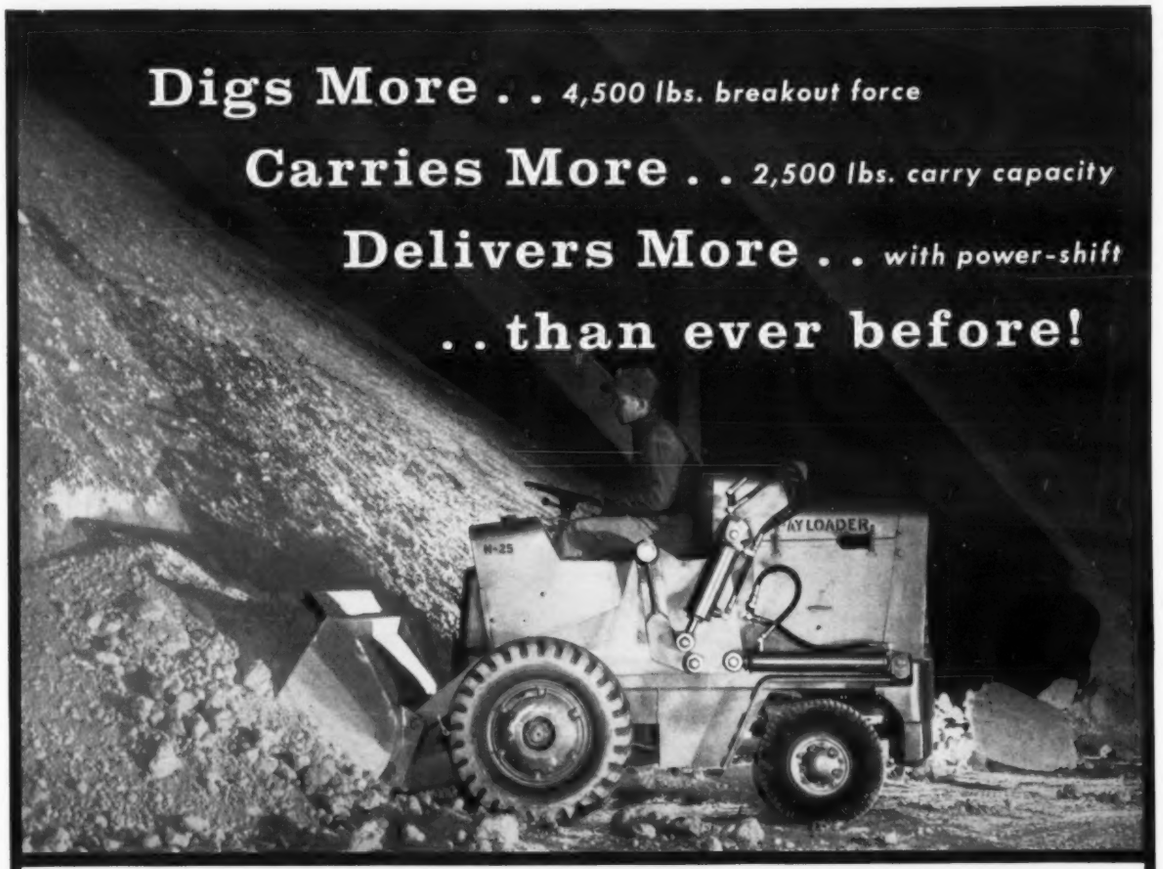
Patternmaking

Construction of Shell Mold Patterns and Core Boxes, W. A. Wright, Woodruff & Edwards, Inc., Elgin, Ill.

Wright offers some primary considerations for designers in attempting to standardize shell equipment:

1) Stabilize the material used to prevent growth and distortion.

2) Use materials with the same coefficient of expansion in a given pattern or core box.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Circle No. 203, Page 7-8

Taylor Zircon Prolongs Ladle Life...

produces cleaner metal too

Taylor Zircon No. 717 Ramming Mix is a most effective lining for ladles handling various types of iron and steel. A St. Louis foundry uses No. 717 exclusively for receiving and pouring ladles in their stainless steel and high alloy operations. They call it the best lining material they have ever used, because:

Photo shows the condition of a Taylor Zircon No. 717 lining of a 500-lb. ladle after 80 days' service in an Indiana foundry. At this plant, one ladle for cast iron and one for steel were lined with Taylor Zircon on the same day. The iron ladle was in service for 205 days; the steel ladle for 119 days . . . both with minor patching. Eight iron heats or six steel heats are melted here in a nine-hour day. How does this compare with your ladle lining life?

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Circle No. 204, Page 7-8

REPORT ON . . . . . .

3) Apply a protective coating to all parts of patterns and core boxes which are threaded. This protects them from seizing.

4) Keep separate cope and drag patterns as uniform in mass as possible so they will expand a like amount at operating temperatures.

5) Radius the external corners of pattern cavities, gates and runners to get a more uniform build-up of shell material in these areas.

In Wright's opinion, the foundry industry should begin to think in terms of standardizing shell machines, patterns, core boxes and auxiliary equipment. The shell customer usually must pay a premium for converting to a different type of machine when he moves his equipment from one foundry to another. This is a deterrent factor in the customer's future decision regarding designing or buying shell mold castings.

A Little Knowledge of Plastics, Robert LeMaster, R. A. Nelson Pattern Co., Milwaukee.

Nelson believes the future of plastics in the foundry industry hinges directly on the plastic formulators' ability to perfect new and better products. These new products must be introduced by trained personnel possessing a thorough knowledge of their trade. They should treat any new product with a degree of pessimism to restrict misapplications, and a degree of optimism to instill progressive thinking. Plastic formulators rely on criticism of patternmakers to better improve their products.

Pattern Standards for Practical Foundry Usage, E. A. Geary, Westinghouse Electric Corp., Trofford, Pa.

Geary reports how his company standardizes patterns by the amount of castings required, relating pattern type with activity. Five classes of pattern equipment are designated for customer use. Class one, low cost, is usually made for one or two castings and then destroyed as the castings are accepted. Class two, usually of wood, is built for production of 50-100 castings during an anticipated period of 10 years.

Class three, machine-mounted wood pattern rigged for a specific molding unit and gated to foundry specifications, is built for 600-800 castings. Class four pattern equipment is designated for low activity, long life items; usually a hardwood pattern mounted for machine molding and reinforced with metal. Class five is designed for high activity and long life, usually fabricated of metal.

Gating and Risering Shell Pattern Equipment, D. C. Kidney, Westinghouse Air Brake Co., Wilmerding, Pa.

Kidney points out some basic principles for improved shell mold gating and risering practice. He summarizes these as follows:

1) Work closely with the foundry in planning equipment.

2) Make a trial run in green sand.

3) Standardize as many items as possible—sprues, basins, runners and strainer gates.

4) To smooth the flow of metal, avoid crossing over in-gates with the runner.

5) Place a basin at the bottom of the sprue to reduce turbulence and aspiration.

6) Extend runners past in-gates to form a by-pass to trap inclusions.

7) Round corners on gates and runners with substantial radii for additional mold strength.

8) Avoid excessive free drop of metal into gates and mold cavities.

9) Arrange the gating system to permit short-pouring times.

10) Do not crowd patterns and gates. Use material for gating compatable with mounting plate.

Construction Hints and Wear Characteristics of Plastic Patterns and Core Boxes, V. E. Zang, Unitcast Corp., Toledo, Ohio.

The use of plastics in duplication of master patterns for production was done to adapt to large diaphragm molding units. Previous patterns were constructed of hard bronze. It was found to be almost impossible to alter these patterns

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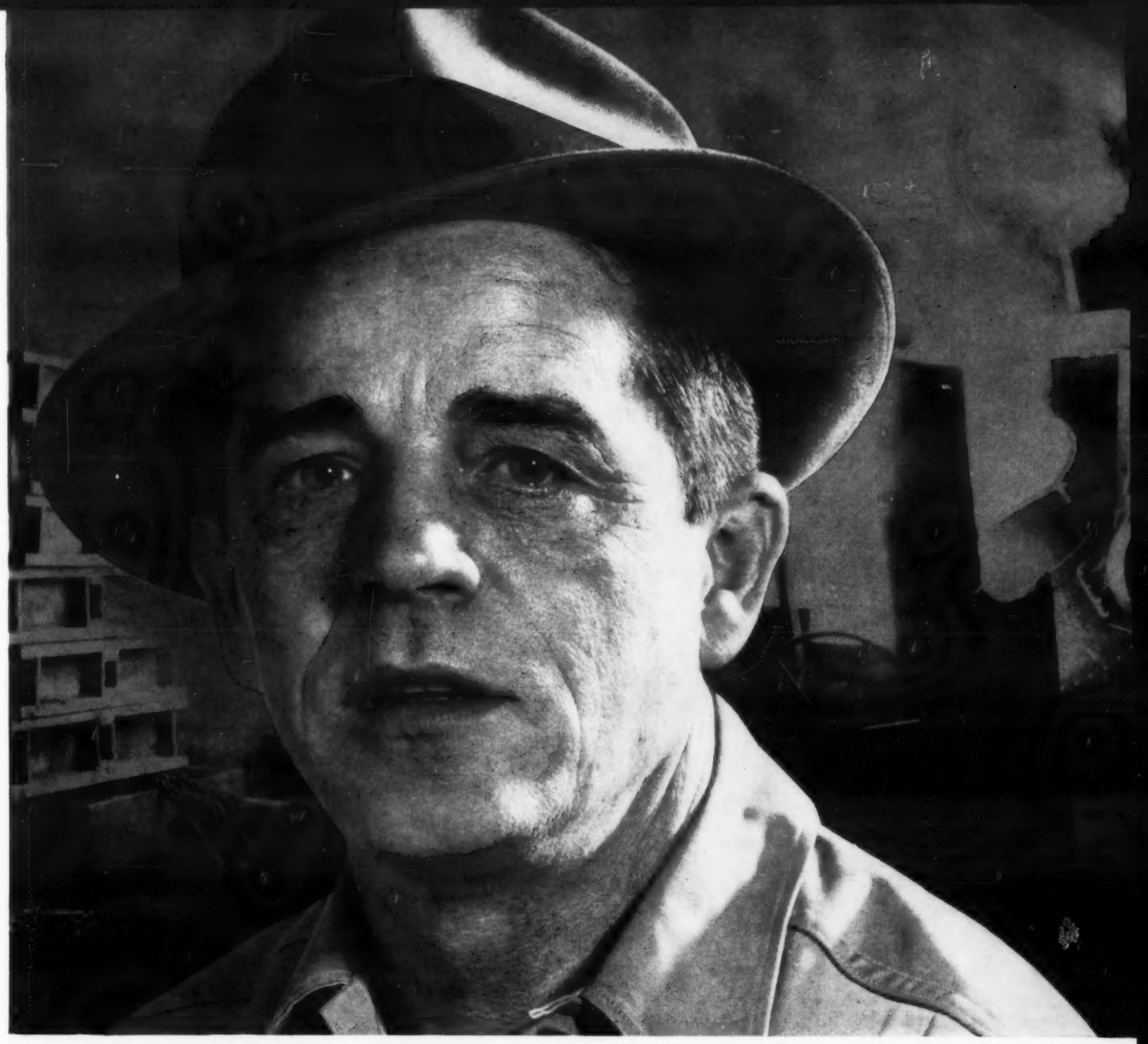

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Foundries find that ELECTROMET's magnesium-ferrosilicon is an economical, convenient source of magnesium for ductile iron. When added to a suitable composition, the alloy gives maximum ductility by promoting a matrix of soft ferrite. By adjusting the analysis, it can easily be used in high-strength irons having somewhat lower ductility.

Magnesium-ferrosilicon is available in grades with or without cerium. Cerium (0.5 or 2%) helps control unwanted residual elements which hinder the formation of spheroidal graphite. For further information and technical assistance, contact your ELECTROMET representative.

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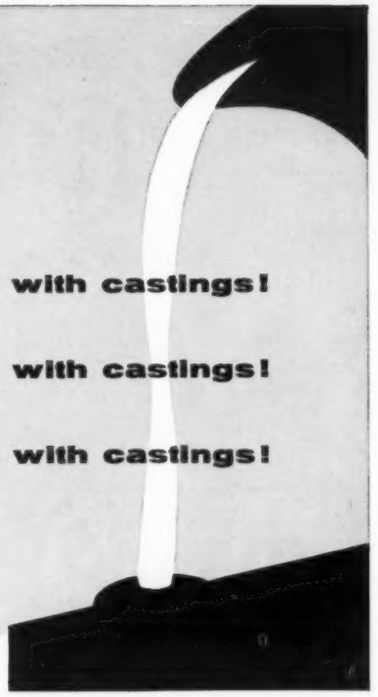

What is the only way to make large metal parts of complex shape economically? . . . . . with castings!

How can you make the most small parts at lowest cost—by the million, if you need to? . . . . . with castings!

What is the best way to make parts with smooth changes of stress flow? . . . . . with castings!

THESE ARE THE FACTS AGGRESSIVE FOUNDRYMEN ARE TELLING, individually and together, through their societies—in the grey iron, nonferrous, malleable and steel fields.

They add one more fact:

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The buyer of castings requires only that his standards for reliable service be met.

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1. STRESSCOAT

The Magnaflux stress analysis tool that shows where high stresses occur—*during your design or pilot runs.* Shows whether stresses are detrimental or harmless. Leads to easy design correction.

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Provides the same testing benefits for *nonferrous* casting control, pilot castings, etc. Starts as low as $125 with new ZA-43 Zyglo Kit shown here.

Also eddy current instruments to control hardness, heat-treat, etc., and sort mixed alloy lots.

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REPORT ON . . . . . .

to suit the new molding technique. Good supporting framework around the body of the pattern proved desirable to avoid extensive cracking during jolting or squeezing.

Cost was found to be one-third to one-half that of metal pattern equipment. Plastic patterns have eliminated the sandslinger process because of wear problems. Engineering modifications are easily accomplished with plaster additions and casting resin.

Steel

The Effect of Vanadium on the High and Low Temperature Mechanical Properties of a 1Cr-1Mo Cast Steel, L. D. Tote and R. S. Zeno, Large Steam Turbine-Generator Dept., General Electric Co., Schenectady, New York.

Purpose of this study was to determine the effect of vanadium content on the high and low temperature mechanical properties of a one per cent chromium, one per cent molybdenum cast steel. Steels were tested in the normalized and tempered condition at comparable hardness levels.

The report revealed the following conclusions:

1) A significant increase in rupture strength occurred at the higher parameter numbers in the range, (M = 36,000-39,500).

2) Increasing the vanadium from 0.04 to 0.22 per cent lowered the rupture ductility.

3) Tensile and yield strengths appeared unaffected as a result of increasing the vanadium content from 0.23 to 0.54 per cent.

4) Increasing the vanadium content from 0.04 to 0.22 per cent increased the energy and fracture appearance transition temperatures approximately 35 C (95 F) and 19 C (66.2 F), respectively.

5) Bainite became finer with vanadium additions to 0.40 per cent, and became smaller with the 0.54 per cent vanadium.

Shell Molding for Steel Castings, R. H. Powell and H. F. Taylor, Massachusetts Institute of Technology, Cambridge, Mass.

This work describes techniques developed which make it possible to adapt shell molding to the man-

ufacture of low-carbon and low-alloy steel castings regardless of section size.

Surface defects generally occurring on low-carbon and low-alloy steel castings in shell molds can be eliminated by the use of chill-type shell molds. Such molds can be made with forsterite or with simple blends of granulated limestone and silica sand.

Best results are obtained when these materials are used in composite shell molds having a thin facing of fine silica sand made by a double investment process.

Improving Electric Furnace Refractory Life by Special Shell Cooling Techniques, V. J. Howard, Oklahoma Steel Castings Co., Div. of American Steel & Pump Corp., Tulsa, Okla.

This paper concerns the cooling glands and variations from standard design of the electric furnace cooling system for the author's company. Howard is convinced that shell cooling properly applied increases refractory life. During 1955, a two-ton, direct-arc, top-charge, acid-lined electric furnace, operating with one cooling gland on a six-day round-the-clock operation, had an average lining life of 331 heats, and roof-life of 487 heats.

Some Factors Affecting the Toughness of Mild Steel Castings, H. H. Fairfield and J. A. Ortiz, Los Angeles Steel Castings Co., Los Angeles.

The investigation concerned the effects of various steelmaking operations during melting as well as the influence of sulfur, carbon and hydrogen on steel ductility. Reduction of area is used as the measure of toughness. Conclusions are as follows:

1) Sulfur over 0.03 per cent causes lowered ductility.

2) Carbon contents above 0.33 per cent result in lower toughness than that found in 0.20-0.30 per cent carbon steel.

3) Each ppm of hydrogen may lower reduction of area by 10 per cent.

4) Boiling the bath improves metal quality.

5) The amount of FeO in the

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In high temperature alloys and corrosion resistant steels, Moly's use has long proven most acceptable. It endows steels with air hardening, increases the depth of hardening, is responsible for an increase in low temperature impact properties, and possesses ability to increase wearing qualities.

Especially to those contemplating new heat treatment or design, molybdenum affords a proven usefulness in assuring desired results. MCA's vast experience in the use of alloys is yours for the asking. If you have a question about molybdenum's potentialities in any ferrous product, write today for the latest technical help.

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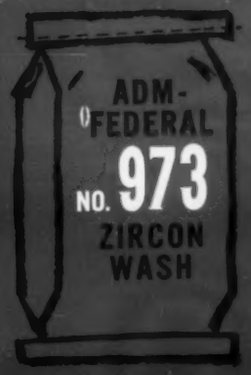
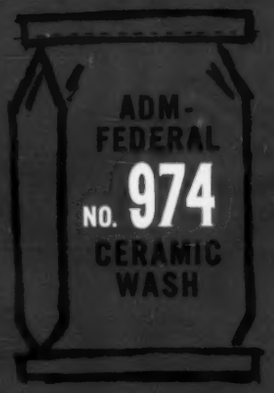
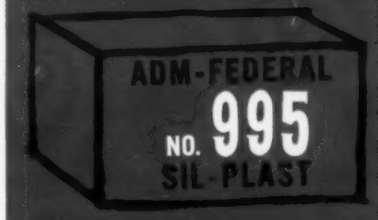
Circle No. 207, Page 7-8

ANNOUNCING...
Three new refractory
ADM·FEDERAL WASHES







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FOR BRUSHING, DIPPING, SWABBING, AND SPRAYING

973 is a water-soluble white powdered pure zircon wash with a working range of 50 to 80° Baume. This is a refractory type wash that resists highest temperatures, thus offering positive protection against metal penetration and burn-in. Except in extreme cases, it is not necessary to use No. 973 zircon wash in its pure state. This wash is completely compatible with No. 974 ceramic wash, and the two may be used in any combination to achieve the desired degree of surface protection. No. 973 zircon wash has excellent suspension properties. Any drying method may be used without developing cracks or blisters.

974 ceramic wash is a white, water soluble refractory-based material in powdered form, having a working range of 28 to 50° Baume. It offers excellent suspension characteristics throughout this wide operating range, and can be torched or oven dried. No. 974 can be blended in combination with No. 973 zircon wash to provide the desired protection at lower cost.

995 SIL-PLAST is a blended plastic refractory-based wash for cores and molds in all types of foundries. Because this material is soluble in either alcohol or water, it is ideal for LINOIL, LIN-O-SET, ADCOSIL, or ADMIREZ cores and molds. In addition, No. 995 SIL-PLAST offers the same wide working range, suspension, and drying characteristics as No. 974 ceramic wash. For ease of handling and elimination of waste, it is packed in 125-lb. polyethylene-lined cartons.

Archer-Daniels-Midland Company
Federal Foundry Supply Division
2191 West 110th Street • Cleveland 2, Ohio
More information, please, on ADM-FEDERAL Wash:
☐ No. 973 ☐ No. 974 ☐ No. 995
Name_____
Title_____
Company_____
Address_____
City_____ Zone___ State_____

AIM TOWARD QUALITY CASTINGS
... the answer to *more business*

Archer Daniels Midland company
FEDERAL FOUNDRY SUPPLY DIVISION
2191 West 110th Street • Cleveland 2, Ohio
Producers of core and mold binders, sea coal, sand stabilizers, core and mold coatings, foundry facings, and "San-Blo" equipment

REPORT ON . . . . . .

slag before tapping has an effect upon reduction of area.

6) Metal in the furnace should always contain FeO to assure against hydrogen pick-up.

7) Tapping temperature must be high enough to allow entrapped non-metallic inclusions to float to the top of the ladle.

8) Tapping must be done so as to prevent slag-metal reaction in the ladle.

Purchase Specifications for Commonly Used Steel Foundry Mold and Core Sand Binders, E. G. Vogel, Lebanon Steel Foundry, Lebanon, Pa.

Materials discussed are bentonite, corn cereal flour, core oil, plastic core binder and cold set oil. Report covers tests involving conventional sand batch properties using standard production sand mix formulas for core oil and liquid phenolic binder evaluations. Purpose of these tests is to control quality of sand binder purchases. Paper lists numerous tests employed and methods and equipment utilized in carrying out the testing program. Vogel comments that the liquid limit test for bentonite is promising since it is quick and may allow discontinuance of other tests.

The Effect of Some Gases on the Work of Adhesion Between a Novolak and Quartz, D. W. G. White, Department of Mines and Technical Surveys, Ottawa, Ontario, Canada, and H. F. Taylor, Massachusetts Institute of Technology, Cambridge, Mass.

This work was undertaken to study quantitatively individual effects of nitrogen, oxygen, water vapor and ammonia on bond strength between phenolformaldehyde resin and a refractory metal oxide.

Compared with surface tension of the resin and work of adhesion in purified helium, 1) water vapor increases the surface tension and work of adhesion by about 10 per cent, 2) nitrogen decreases the surface tension of the resin and the work of adhesion by a questionable amount and 3) ammonia in-

Circle No. 208, Page 7-8

creases the surface tension and adhesion by about 20-30 per cent.

The report concludes that oxygen may react with a thermosetting resin in shell molds in the 2-3 min that the resin is hot, to an extent that is worth curtailing. It may not be practical to make shell molds in a controlled atmosphere, but the possibility of precoating sands for shell molds in the absence of oxygen may be commercially feasible.

Some Remarks on the Relationship of Interface Temperature and Solidification, V. Paschkis and J. W. Hlinka, Columbia University, New York.

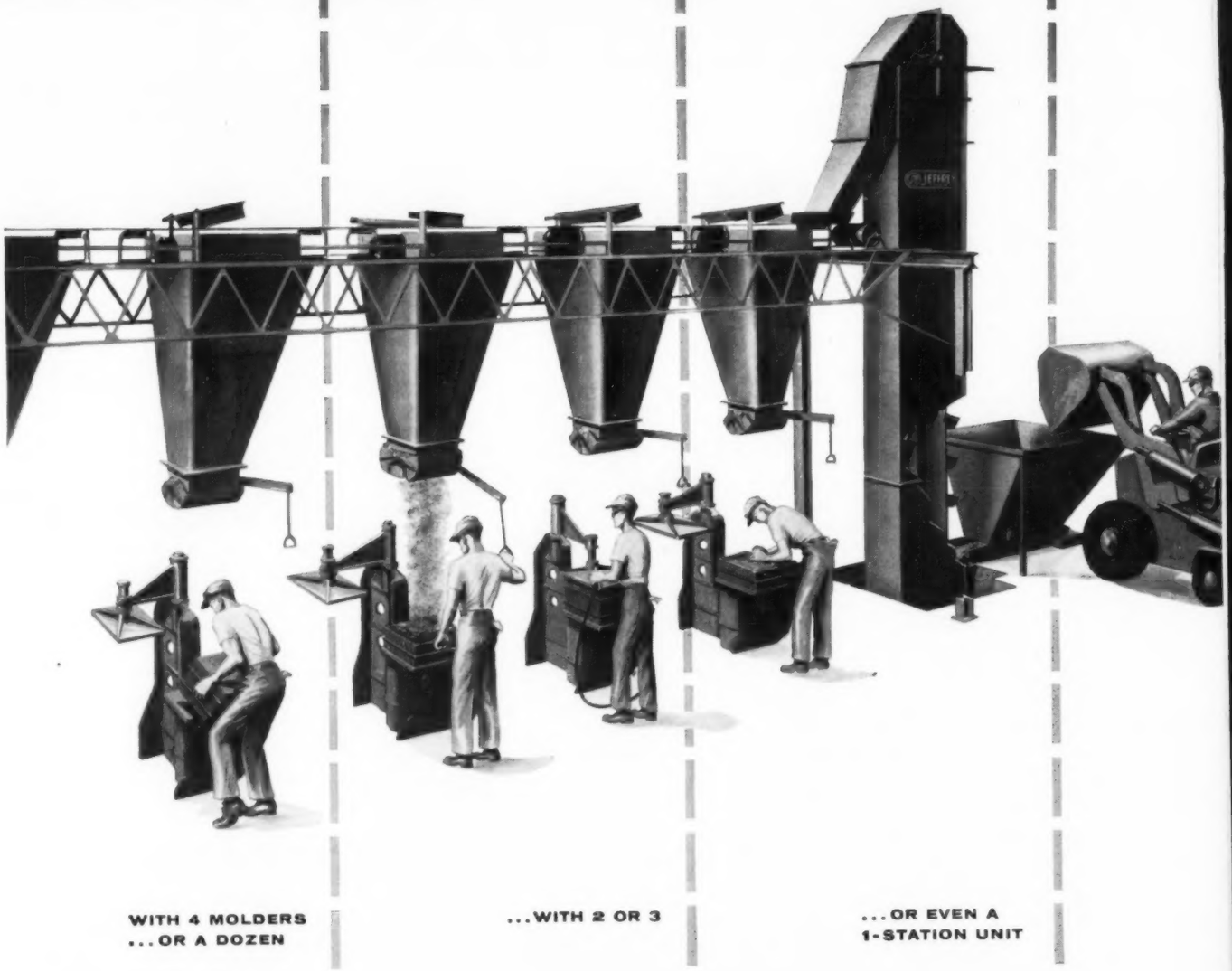
Conclusions are presented on work done on pure metals (freezing at a constant temperature) rather than for alloys (freezing over a range). Results are shown for iron cast in sand or chill and two other molds materials. Results are interesting because they hold, at least qualitatively, also for steel and non-ferrous pure metals such as aluminum. The study developed a chart which allows determination of total freezing time for a large slab (no end effects) of any pure material or cast eutectic alloy, providing conductivity of the solid casting is twice that of the liquid.

Fundamental Studies on Effects of Solution Treatment, Iron Content and Chilling of Sand Cast Aluminum-Copper Alloy, E. M. Passmore, M. C. Flemings and H. F. Taylor, Massachusetts Institute of Technology, Cambridge, Mass.

It is known that chilling, together with close control of other foundry variables, may be used to substantially raise the mechanical properties of aluminum alloy castings. This present work was undertaken to determine if greater control of the solution-treating operation or of impurity content might be effective in substantially improving the properties of sand-cast aluminum-copper alloys.

The investigation has shown that chilling affects the structure of such castings by 1) refining the size and distribution of $CuAl_2$, 2) refining the size and distribution of impurity intermetallic com-

Continued on page 138



Speeds production...cuts molding costs

JEFFREY OVERHEAD SAND SYSTEM

Here's automation which can be *profitably* applied to small foundries as well as big ones . . . the low-cost, easy-to-install Jeffrey overhead sand system. Whether you have a single molding station or a dozen, it will speed production and reduce your molding costs.

Sand is always available at the molding machine and it doesn't have to be lifted from the floor. Molders' time is saved, their work made easier when sand flows directly from overhead hoppers into the flasks.

These Jeffrey overhead sand units were designed to bring big-foundry advantages to small foundries . . . at low cost. Built as package units, savings in engineering and manufacturing costs are passed along to you. For complete information, get in touch with The Jeffrey Manufacturing Company, 977 North Fourth Street, Columbus 16, Ohio.

JEFFREY

CONVEYING • PROCESSING • MINING EQUIPMENT...TRANSMISSION MACHINERY ...CONTRACT MANUFACTURING

Circle No. 209, Page 7-8

foundry trade news

MALLEABLE FOUNDERS' SOCIETY . . . Cleveland, held their 9th Market Development Conference April 9-10, Edgewater Beach Hotel, Chicago. G. T. Boli, president, Northern Malleable Iron Co., St. Paul, Minn., spoke on *"Creative Selling—for the Small Foundry"*. *"Creative Selling —for the Large Foundry,"* was covered by J. H. Smith, general manager, Central Foundry Division, GMC, Saginaw, Mich.

L. R. Jenkins, Wagner Malleable Iron Co., Decatur, Ill., explained *"Elevated Temperature Behavior of Malleable"*; W. C. Truckenmiller, Albion Malleable Iron Co., Albion, Mich., discussed new data developed by the Society's research program entitled *"Malleable Machining Characteristics."* G. J. Kramer, Central Foundry Div., GMC, spoke on *"Sales Value of Machining Data."*

First prize in Redesign and Conversion Contest was awarded at the Society's dinner to W. T. Cole, vice-president, Canton Malleable Iron Co., Canton, Ohio. Other winners were: J. L. Flitz, Central Foundry Division, GMC; Hugh Pope, Eastern Malleable Iron Co., Wilmington, Del.; J. R. Entenmann, Northern Malleable Iron Co., St. Paul, Minn.; N. V. Stickney, Superior Steel & Malleable Castings Co., Benton Harbor, Mich.; Neal Narajoa and Tony Martin, Texas Foundries, Inc., Lufkin, Texas.

Cole was successful in converting T-bolts from forgings into pearlitic malleable iron castings. Flitz employed stress analysis to design and subsequently to redesign a rear spring clip. Pope designed shell-molded pearlitic castings to be used for plier frames—eliminating machining. Entenmann redesigned a wagon hoist cross.

Wayne Aluminum Foundry . . . Garden City, Mich., attracts the attention of many out-of-state buyers with an animated display at Willow Run Airport near Detroit. Robotized foundrymen go through the motions of pouring aluminum castings. Wayne's policy is to serve the small customer first, as generally the volume buyer has time to plan and schedule operations well in advance.

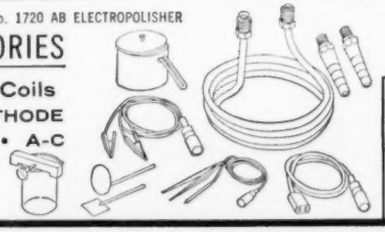
NEW AB ELECTROPOLISHER FOR METALLOGRAPHIC SAMPLES

- SIMPLICITY IN OPERATION
- INTERCHANGEABLE ELECTROLYTE TANK
- IMPACT and CORROSION RESISTANCE
- EASY TO FILL and EMPTY
- CONVENIENT ELECTROLYTE STORAGE
- COMPLETE ELECTRICAL INSULATION
- INCREASED SAMPLE AREA
- GREATER ELECTROLYTE CAPACITY
- VERSATILE POWER SOURCE
- D. C. RIPPLE CONTROL
- FIELD TESTED and APPROVED
- REASONABLY PRICED

No. 1720 AB ELECTROPOLISHER

AVAILABLE ACCESSORIES

Extra Tanks • Cooling Coils
Extensions: ANODE-CATHODE ETCHING • A-C
Cathodes for Etching
Cathode Holders



Buehler Ltd.
METALLURGICAL APPARATUS
2120 GREENWOOD ST., EVANSTON, ILLINOIS, U.S.A.

Circle No. 210, Page 7-8

OLIVER BAND SAW

takes 35" under guide to saw extra large patterns

This new Oliver is powerful and sturdy. Gives clearance for sawing large patterns, jigs and fixtures. Has 36" diameter wheels. Cuts true and steady without vibration at all speeds. Motor-on-shaft unit, and latest features. Write for Bulletin 116DH.

Oliver Band Saws also made in 38", 30", 18" sizes.

OLIVER MACHINERY COMPANY
Grand Rapids 2, Mich.

Circle No. 211, Page 7-8

head from a weldment to a standard malleable iron casting. Stickney designed a standard malleable casting which gave a bonus of easier installation and adjustment. The sixth prize winners, Naranjo and Martin, redesigned a spring seat used in the wheel suspension system of a boat trailer.

J. H. Smith

Last day's session included *"How Customers See Us,"* and malleable iron buyers gave opinions of, and attitude toward, the industry. Speakers were: Howard Williams, vice president-purchasing, Eaton Manufacturing Co., Cleveland; Lawrence Miles, manager-value analysis, General Electric Co., Schnectady, N. Y.; and Roger B. Huffman, chief engineer, Duplex Truck Div., Warner & Swasey Co., New Philadelphia, Ohio.

GRAY IRON FOUNDERS' SOCIETY . . . announced the annual 1958 Design Contest by sending nearly 20,000 folders to a selected list of designers, engineers and foundrymen throughout the United States and Canada. Contest deadline is June 20, 1958.

Every bona fide entrant will win a copy of the new Gray Iron Castings Handbook, edited by C. F. Walton, G.I.F.S. technical secretary. Primary purpose of the contest is to give due recognition to designers and engineers of gray iron and ductile iron castings. Entries will be judged on 1) how the design, or redesign, did or could increase efficiency of product; 2) cost saving; 3) potential commercial importance to gray iron industry as a whole and 4) ingenuity of design.

Judges will be a group of industrial foundrymen, headed by E. J. Tangerman, editor, Product Engineering magazine. Anyone connected with

1904—In this modest 3000 sq. ft. plant, Thomas L. Smith, early leader of our company, with 10 Sterling men, began the manufacture of wheelbarrows.

an old friend with a new name

Sterling is pleased to announce a change in the company name. Instead of *Sterling Wheelbarrow Company* . . . a familiar and respected name throughout the foundry industry . . . the firm will hereafter be known as

STERLING NATIONAL INDUSTRIES, INC.

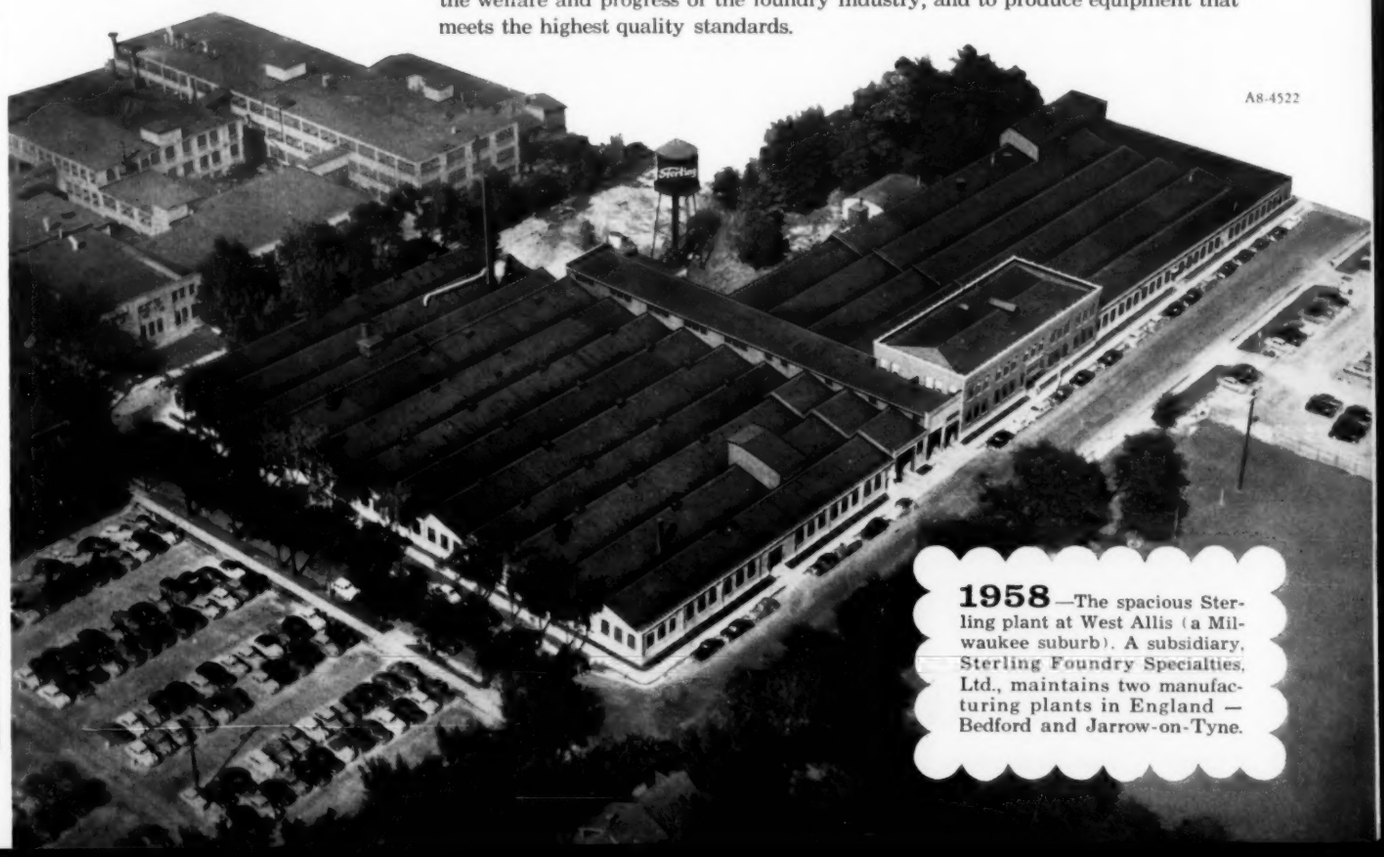
MILWAUKEE 14, WISCONSIN, U. S. A.

Sterling

Foundrymen may have wondered why the name Sterling Wheelbarrow Company . . . why not call it Sterling Foundry Equipment Company. Originally . . . as far back as 1904 . . . Sterling produced wheelbarrows, exclusively. The company did an excellent job of designing and building wheelbarrows for "roll easy" heavy duty performance. This inspired demands from the trade for other Sterling equipment and paved the way for the well-known line of Sterling Foundry Flasks and other foundry equipment.

Today, Sterling has a world-wide reputation for high quality, engineered-to-the-job design. And the extensive Sterling line of foundry equipment, including wheelbarrows, carts and trucks, meets a wide range of standard applications. In addition, equipment can be custom-built to meet special foundry requirements.

Sterling National Industries desires to continue the Sterling policy of working for the welfare and progress of the foundry industry, and to produce equipment that meets the highest quality standards.



1958—The spacious Sterling plant at West Allis (a Milwaukee suburb). A subsidiary, Sterling Foundry Specialties, Ltd., maintains two manufacturing plants in England — Bedford and Jarrow-on-Tyne.

WEDRON

A COMPLETE LINE OF 24 DIFFERENT PROCESSED SILICA SANDS

A CONTROLLED GRADE FOR EVERY CASTING NEED!

SAND SPECIFICATIONS — REPRESENTATIVE SCREEN ANALYSES

Unground Sand	4098	4085	4060	4040	4030	4020	5040	5030	5025
Ret on 20 Mesh	2.2								
Thru 20 ret on 30	38.6	12.4	5.6	0.6	0.4	0.4			
Thru 30 ret on 40	57.6	70.8	56.2	37.2	30.2	21.2	4.0	1.2	0.6
Thru 40 ret on 50	1.4	16.3	34.8	52.0	55.8	51.4	34.8	30.4	23.8
Thru 50 ret on 70	0.2	0.5	2.8	9.0	11.4	20.6	44.4	48.2	42.0
Thru 70 ret on 100			0.6	1.0	1.8	5.2	14.4	17.8	26.4
Thru 100 ret on 140				0.2	0.4	1.0	2.0	2.0	6.2
Thru 140 ret on 200						0.2	0.4	0.4	0.8
Thru 200 ret on 270									0.2
Grain Fineness (AFS)	25.88	30.49	33.72	37.48	38.82	42.22	49.96	51.64	56.90

Unground Sand	5015	5010	5005	7030	7020	7010	C-30	C-10
Ret on 20 Mesh								
Thru 20 ret on 30								
Thru 30 ret on 40	1.2	0.4	0.2	0.2	0.2			
Thru 40 ret on 50	15.2	11.2	4.4	3.0	2.4	0.4		
Thru 50 ret on 70	40.2	35.2	31.2	26.2	18.0	8.2	0.4	0.2
Thru 70 ret on 100	35.4	37.4	41.2	42.0	45.0	46.6	28.4	8.4
Thru 100 ret on 140	6.4	10.8	15.4	16.4	20.0	23.2	44.8	50.2
Thru 140 ret on 200	1.2	4.0	5.6	9.6	11.0	15.4	18.8	28.2
Thru 200 ret on 270	0.4	0.8	1.4	1.8	2.4	4.2	5.0	8.8
Thru 270 ret on 325		0.2	0.6	0.8	1.0	2.0	2.6	4.2
Grain Fineness (AFS)	60.20	66.92	73.92	79.36	84.42	95.44	108.22	124.60

Ground Sand (Flour)	80M	100M	140M	200M	300M	325M	400M
Ret on 60 Mesh	10/20%						
Thru 60 ret on 100	25/30%	5%					
Thru 100 ret on 140	15/20%	14%	4%	1%			
Thru 140 ret on 200	10/15%	16%	6%	4%	2%	Trace	
Thru 200 mesh	25/40%						
Thru 200 ret on 270		10%	12%	6%	2%	0.5%	Trace
Thru 270 ret on 325		12%	8%	9%	11%	4.5%	2%
Thru 325 mesh		43%	70%	80%	85%	95.0%	98%

99.9% PURE SILICA WEDRON SILICA COMPANY INDUSTRIAL SAND

FINE SHELL MOLDING SANDS
STANDARD CASTING SANDS — BLASTING SANDS
SILICA FLOUR — LIGHT METAL CASTING GRADES

Wedron offers you a complete line up of casting sands — anything needed for every *casting* need! This means you get the advantages of one source of supply for all the sand you need — sand of the highest quality, too.

Now this Wedron quality stems from two factors. First is the naturally rounded grain sand of the Ottawa-Wedron district (this is held to be one of the purest silica sand deposits in the nation). Second is the modern, completely equipped Wedron plant, which turns out a superior silica product and makes all grades available.

Look to Wedron for the *complete* line of quality casting sands.

MINES AND MILLS IN THE OTTAWA-WEDRON DISTRICT

WEDRON SILICA COMPANY

135 SOUTH LASALLE STREET, CHICAGO 3, ILLINOIS

Circle No. 213, Page 7-8

the metal-working industry is eligible to enter the contest.

INVESTMENT CASTING INSTITUTE . . . members will meet for their Annual Technical Session, June 23-25, in Muskegon, Mich. The three-day session is designed for key executives and technical staffs of member companies.

Activities will include plant visitations, technical talks and discussions. Dr. R. A. Flinn, University of Mich., Ann Arbor, will speak on, "*Pressure Poured Precision Casting in Graphite Molds.*" The future of vacuum alloys and anticipated fields of application will be discussed by F. S. Badger and W. H. Hunter., Haynes Stellite Co., Kokomo, Ind.

Among other features of the meeting will be a Cost Estimating Panel discussing, "Quoting for Profit." The panel will include engineering and accounting personnel from Misco Precision Co., Whitehall, Mich.

The Institute has announced the availability of the Second Edition of Investment Casting Engineering and Design Manual. The manual contains information on advantages and limitations of the process; investment casting metallurgical specifications; specific recommendations for designing including tolerances that can be expected and case studies of products that have been economically transformed into investment castings. Copies can be purchased directly from the Institute.

AMERICAN ZINC INSTITUTE . . . announced through J. L. Kimberley, executive vice-president, the appointment of A. R. Cook as market development engineer. Cook was formerly sales development engineer for Northern Aluminum Co., Ltd., Banbury, Oxfordshire, England.

MAGNESIUM ASSOCIATION . . . released tonnage figures based on information received from the Bureau of Census, U. S. Dept. of Commerce. A bright spot in figures of magnesium casting shipments for February was the increase of 13 per cent shown by sand castings. Total shipments were off four per cent against January shipments and were one-third under February, 1957.

SUMMARY OF U.S. MAGNESIUM CASTING SHIPMENTS

(Short Tons)

	Sand	Perm. Mold	Anodes	Die	Total
Feb 1958	479	44	306	72	903
Jan 1958	423	52	346	120	940
Feb 1957	698	112	315	206	1331

Despite a shorter month, increase in magnesium sand casting shipments

from 23 tons to 79 tons was heartening. Permanent mold shipments and anode shipments held close to January totals.

NATIONAL FOUNDRY ASSOCIATION . . . survey shows wood patternmakers employed in the steel foundries are highest paid group of foundry workers. Average hourly earnings (straight-time, day work) is above $3.10. Wood patternmakers in gray iron and malleable shops earn $2.82, and non-ferrous foundries pay on an average, $3.05. Average hourly pay in 1,280 foundries, employing 123,320 personnel, based on 26 key classifications, is $2.03—gray and malleable; $2.23—steel; $2.12—non-ferrous. N.F.A. report gives a more detailed breakdown in specific areas.

AMERICAN DIE CASTING INSTITUTE, INC. . . . stated 1957 was third best year for die casters. Overall production and sales were exceeded only in 1955 and 1956, according to their annual report. Production of die castings of aluminum reached a new high level in 1957 despite a precipitate drop in fourth-quarter production as a result of general decline in the economy.

David Laine, Institute secretary, states, "the impact of increased *hot metal* aluminum operations by captive automotive die casting facilities during last year seriously handicapped ability of custom die casters to compete for this business".

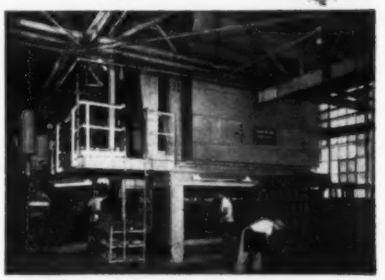
In 1957 die castings accounted for a larger share of total non-ferrous castings production, as in 1956. Proportion of total aluminum castings production going to die castings for the year was 49 per cent as compared with 47.3 per cent in 1956 and 43 per cent in 1955. Although the automotive industry continues to be largest single consumer for die castings, last year saw greater diversification of applications. The Institute states further stimulation of markets such as business machines, agricultural equipment, photographic, scientific and optical devices, toys and sporting goods is indicated.

MATERIAL HANDLING INSTITUTE, INC. . . . Pittsburgh, Pa., released the Booking Index based on monthly orders reported by Association of Lift Truck and Portable Elevator Manufacturers, Caster and Floor Truck Mfg. Assoc., Conveyor Equipment Mfg. Assoc., Industrial Truck Assoc., and Monorail Mfg. Assoc. Dollar volume of incoming orders booked in February was 93.49 using 1954 as

Continued on page 141

COLEMAN OVENS

turn minutes into money...



Coleman Tower® Oven

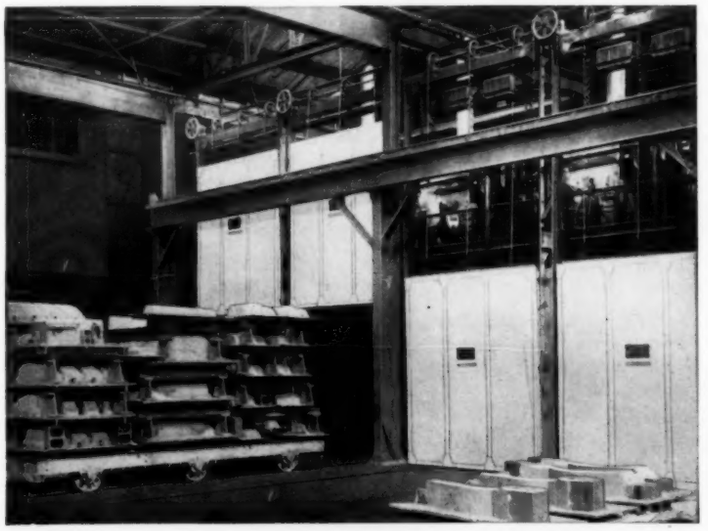
Fast, efficient production of uniformly good cores and molds is vitally important to foundry profits.

When you use old, out-dated core and mold ovens the minutes and hours lost in costly rejects and make-overs . . . the time and effort lost in wasted man power, the production lost in casting scrap eat your profits away. Modern design and exclusive advantages of Coleman Ovens result in immediate production economies, reducing overall core department costs by as much as 50%! Such savings mean increased profits and rapid investment amortization.

More than half a century of specialized foundry oven experience is your assurance that the Coleman Oven recommended to you will do your work to your complete satisfaction. ***As builders of the world's only complete line of foundry ovens we have no reason to recommend any but the best for your purpose.*** Let our experienced engineers give you practical suggestions for your particular requirements.

WRITE FOR BULLETIN 54

Coleman Transrack Ovens



Coleman Car-Type Core Ovens

Coleman Dielectric Oven

A COMPLETE RANGE OF TYPES AND SIZES . . .
for every core baking and mold drying requirement:
Tower Ovens • Horizontal Conveyor Ovens
Car-Type Core Ovens • Car-Type Mold Ovens
Transrack Ovens • Rolling Drawer Ovens
Portable Core Ovens • Portable Mold Dryers
Dielectric Core Ovens

THE FOUNDRY EQUIPMENT COMPANY
1825 COLUMBUS ROAD **CLEVELAND 13, OHIO**

WORLD'S OLDEST AND LARGEST FOUNDRY OVEN SPECIALISTS

Circle No. 214, Page 7-8

SIZED TO FIT *YOUR* CUPOLA

You can choose from 5 sizes when you specify Semet-Solvay Foundry Coke. Each is the best you can buy—uniform in analysis, sturdy and blocky in structure. Call your Semet-Solvay man today.

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Western Distributor: WILSON & GEO. MEYER & CO., San Francisco

For Better Melting

Circle No. 215, Page 7-8

Bucyrus-Erie Co. installs ARCAIR—saves time in Clean-up of Castings

Bucyrus-Erie Co. has installed Arcair for foundry cleaning room operations at its Erie (Pa.) Works.

With three conditioning booths equipped with Arcair torches, considerable time is being saved in casting clean-up — removal of riser stubs, flash, inclusions and defects. And operators learned the process easily and quickly.

You too can save with Arcair! Basic simplicity — electric arc plus ordinary compressed air — makes Arcair the new, efficient, cost-cutting answer to your metal removing problems.

Send today for full information!

Arcair **Metal Removal Torches**

441 S. Mt. Pleasant St., Lancaster, Ohio

Circle No. 216, Page 7-8

Build an idea file for plant improvements. Reader Service Cards, page 7-8 will bring more information . . .

for the asking

Epoxy-alloy . . . described in announcement that explains new composition extending benefits of plastic tooling. Six case histories of excellent results in long-production runs. Used for low-production draw dies; opens new tooling market. *Bakelite Co.*
Circle No. 101, Page 7-8

CO_2 shell molding . . . development reviewed. New process and advantages of being non-inflamable and non-gas forming is described. *Philadelphia Quartz Co.*
Circle No. 102, Page 7-8

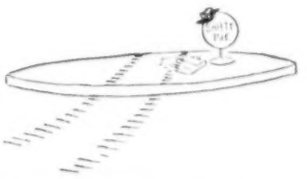
Sponge iron . . . melting stock explained in brochure. Advantages are said to be regularity of melting operation and uniformity of steel analysis. Analysis is given as well as applications and benefits. *Hoeganaes Sponge Iron Corp.*
Circle No. 103, Page 7-8

Microstructure . . . of gray iron castings illustrated in 12-p booklet showing micrographs of castings with from 31,500 to 63,000 psi. Company claims that, through patented ionization method of control, dependable gray iron castings are available for customers demanding machinability, solidity, economy, uniformity, dependability and guaranteed mechanical properties. *Herbert A. Reese and Associates.*
Circle No. 104, Page 7-8

Beryllium . . . discussed relative to industrial hygiene aspects of beryllium metal, beryllium oxide and beryllium alloys. Pamphlet, 13 pp, also covers the effect of the metal regarding ingestion cuts, radiation, fire and explosion, and air contamination control. Titled "Plain Talk on Beryllium" publication also includes bibliography and list of beryllium characteristics. *Beryllium Corp.*
Circle No. 105, Page 7-8

Vibratory screen . . . catalog, 14 pp, lists complete data and specifications on pulsating-magnet screens, concentric-action screens, unbalanced-pulley screens, bar screens and screening feeders. Vibratory bulk materials handling equipment illustrated with photographs of typical applications and installations. *Syntron Co.*
Circle No. 106, Page 7-8

Street and highway safety . . . emphasized in 29-p booklet including many cartoons based on safe driving. Also contains articles and tables pre-



senting a multitude of accident statistics for 1957. Learn how you can be as safe going to work as you are in the shop. *Travelers Insurance Co.*
Circle No. 107, Page 7-8

Investment (lost wax) process . . . evaluation in monthly newsletter. Successful use in metalcasting analyzed — cost versus production, tolerances. *The Metal Castings Advisor*
Circle No. 108, Page 7-8

Infrared lamps . . . for use in industrial applications of heating, drying and baking are pictured in various applications in brochure. Gives rundown on how infrared works, advantages, how it is used in industry, planning installation and determining power requirements. *Sylvania Electric Products Inc.*
Circle No. 109, Page 7-8

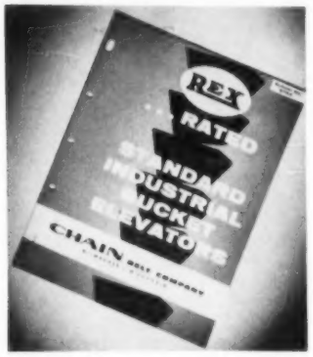
Electric lift truck . . . with capacity of 3000 lb described in bulletin. Gives tables of dimensions, capacity, speeds, details of design and construction, and pictures of components. *Baker Industrial Trucks, Div. Otis Elevator Co.*
Circle No. 110, Page 7-8

Reference catalog . . . 16-pp, gives complete summary of products. Alphabetic listing of over 1500 products includes: alloys and metals; carbon products; chemical products; industrial gases and equipment; plastics;

nuclear products; and consumer products. Shows sales offices by state and city, and trade marks. Handy guide in obtaining foundry needs. *Union Carbide Corp.*

Circle No. 111, Page 7-8

Bucket elevators . . . described and well illustrated with line drawings in 35-p booklet. Recommends specific



elevators for various materials, points out features, lists specifications and components and accessories. *Chain Belt Co.*

Circle No. 112, Page 7-8

Copper alloy . . . containing 2 per cent lithium for producing dense, nonporous castings described in brochure. Also covers boron aluminum for grain refining. *Continental Copper and Steel Industries, Inc.*

Circle No. 113, Page 7-8

Wheelabrator fellowship . . . program explained in detail in 8-p brochure. The grant will enable the Foundry Educational Foundation to award 50 fellowships of $1500 each during the next 10 years. For more information about this program Circle No. 114 on Reader Service Card, page 7-8 *Foundry Educational Foundation.*

Safety glasses . . . booklet detailing construction and safety features of two-tone plastic ultrascopic safety glasses. Manufacturer claims glasses to be shatter-proof, dielectric, flame-resistant, strong and lightweight. *American Optical Co.*

Circle No. 115, Page 7-8

Machining manual . . . 22-pp, contains guide for machine feeds and speed, includes quantity-weight slide rule calculator, and other basic information. *Kaiser Aluminum & Chemical Sales, Inc.*

Circle No. 116, Page 7-8

Index . . . to 1957 issues of MODERN CASTINGS available. Valuable cross-reference by subject, author and company enables reader to find material quickly and with a minimum of

Allis-Chalmers Trucks with TRI-LIFT Masts

STACK NEARLY ½ HIGHER

YET WORK IN LOW HEADROOM

Allis-Chalmers 4,000-lb fork truck with Tri-Lift mast enters a low-headroom truck at the loading dock.

Here the same truck reaches high for efficient yard stacking, with its Tri-Lift 144-in. mast.

STORES MORE MATERIAL — Wherever there's room above for stacking, an Allis-Chalmers Tri-Lift truck gives you up to 50 percent extra storage space at your "fork tips." No penalty when you work around low overhead obstructions, either.

OPERATES IN ENCLOSED TRAILERS AND BOXCARS — In addition to reaching up nearly one-half higher, an Allis-Chalmers Tri-Lift mast, when lowered, ducks through low doorways or into enclosed trailers and boxcars.

IT'S SIMPLE, WITH GOOD VISIBILITY — Uses only a single, standard lift cylinder — like any conventional mast. No complicated ratchets or latches. This simplicity means more visibility through the mast.

FIND OUT MORE — Call your Allis-Chalmers material handling dealer. He'll be glad to demonstrate the advantages of Tri-Lift mast. He'll help you select the "years-ahead" model and capacity truck that will best suit your particular needs. You may have detailed literature by writing direct. Allis-Chalmers, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS A-C ALLIS-CHALMERS

RH 76

Circle No. 217 Page 7-8

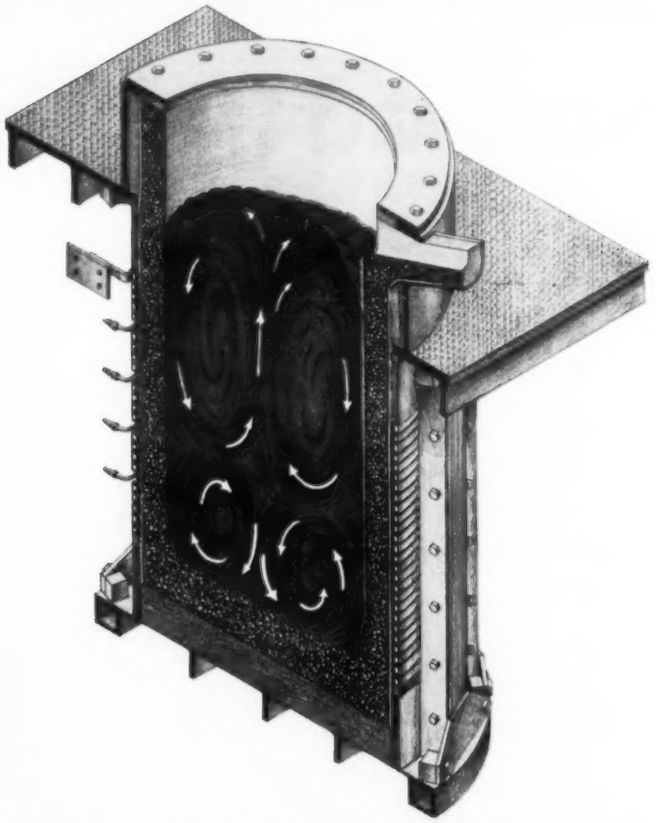
a new principle in 60 Cycle induction melting

WHAT IT IS

WHAT IT CAN DO

May We Explore the Possibilities of this New Method with You?

AJAX-JUNKER



- A cylindrical induction coil supplied with ordinary 60 cycle current induces heat and vigorous electromagnetic stirring in the molten metal charge.

Integrated electric controls regulate power, maintain high power factor automatically.

Monolithic refractory linings are made by ramming against the sturdy water-cooled coil held in a rigid frame of magnetic and structural steel.

This new principle was perfected in Europe over the last seven years. Over 100 Junker furnaces are now in use. AJAX-JUNKER designs are based on latest experience, using American components and practices throughout.

- Outstanding results are proven in these fields:

DUCTILE and ALLOY IRON CASTINGS
RECOVERY OF IRON TURNINGS
RECOVERY OF ALUMINUM SCRAP

Available sizes range from 1 to 10 tons, with normal melting cycles from 2 to 4 hours. Power ratings are 200 kw through 1500 kw.

AJAX USA

60 CYCLE INDUCTION MELTING

ENGINEERING CORPORATION

TRENTON 7, NEW JERSEY

Associated Companies: Ajax Electrothermic Corporation Ajax Electric Company

Circle No. 218, Page 7-8

effort. For your free copy circle No. 117, Reader Service Card, page 7-8.

Color code kit . . . offered including materials and data necessary to design a reportedly successful color coding system. Useful for identification of

crates, boxes or products "in process," foundry materials, castings and scrap. *Crown Industrial Products Co.*

Circle No. 118, Page 7-8

Coated work gloves . . . a new line, is presented in catalog. Neoprene, plastic and rubber coated gloves listed, with advantages including liquid-proof, acid-resistant, protection against solvents and abrasives, positive grip. *Riegel Textile Corp.*

Circle No. 119, Page 7-8

Machining Meehanite castings . . . subject of 20-p booklet covering machining data of various types of castings, divided according to the type of machine tool used. Useful as set-up guide. Gives details regarding feeds, speeds, depths of cut and type of tool. *Meehanite Metal Corp.*

Circle No. 120, Page 7-8

Band saw guides . . . catalog and operating manual depicts three different types of guides in wide range of models and sizes plus newly developed line of universal mounting brackets claimed to fit the guides on any standard band saw. Also includes numerous rules and suggestions pertinent to band-sawing operations in the foundry. *Carter Products Co.*

Circle No. 121, Page 7-8

Refractory castables . . . reference booklet, 24 pp, includes table of proper applications for 15 specialized castable refractory cements. Contains information on anchoring castables, mixing and placing instructions, suggestions for pneumatic placement of castables and other information helpful to foundrymen when lining furnaces. *Mexico Refractories Co.*

Circle No. 122, Page 7-8

Salt bath furnace . . . catalog, 76 pp, covers heat-treating equipment information and presents technical data including austempering and martempering curves, charts showing penetration times for carburizing, heating rates for typical steels and other fac-

tors. Illustrates company's line of heat treating furnaces and new ceramic tile pot furnaces with removable submerged electrodes. *Ajax Electric Co.*
Circle No. 123, Page 7-8

Stamping industry . . . uses for Strenes metal, a chromium-molybdenum alloyed gray iron, outlined in data file. Includes brochures on castings for automotive industry, ductile iron, metal castings. *Advance Foundry Co.*
Circle No. 124, Page 7-8

Centrifugal fan . . . 37-p bulletin describes complete line of backward-blade fans designed for use in heating-ventilating and air-conditioning systems, power plant installations and industrial processes. Includes engineering data, specifications, performance tables. *General Blower Co.*
Circle No. 125, Page 7-8

Materials handling conveyors . . . illustrated in new book including 24 case histories, 16 diagrams of conveyor systems solving complete handling problems, 12 sketches illustrating functions of conveyors and 50 views of installations. Company claims book of particular interest to foundry production officials. *Logan Co.*
Circle No. 126, Page 7-8

free films

■ **Motion pictures and other visual aids based on foundry processes and supplies are also yours *for the asking*. These films are suggested for formal or informal training groups. The owners of films in this column will send booking request forms to MODERN CASTINGS readers who circle the appropriate number on the Reader Service card (page 7-8).**

Operation of a Small Jobbing Foundry . . . 16 mm, black and white, silent, 60 min. Film produced to familiarize non-foundrymen with operations and necessary care used in production of castings. Relates amount of labor and skill required to produce castings. *Chemung Foundry Corp.*
Circle No. 127, Page 7-8

Shell Molding . . . 16 mm, black and white, sound, 18 min. Film covers wide range of shell production methods from manual operations to huge multi-station machines. Also traces development of resin shell binders. *Monsanto Chemical Co.*
Circle No. 128, Page 7-8

Safety for Sale . . . slidefilm, 73 pictures, 74 frames. Supervisor's or foreman's responsibility for plant safety, and ways of avoiding dangerous practices. *Jam Handy Organization.*
Circle No. 129, Page 7-8

Circle No. 219, Page 7-8

WE RECOMMEND THIS M(a)n

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SITUATION WANTED

FAMILY man with 30 years industry wide experience. Qualified in open hearth, electric furnace and foundry practice. Remuneration expected in keeping with performance, good work record. References furnished upon request.

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We hope this ad will emphasize a condition currently existing in our industry.

Due to current economic conditions abroad, imported manganese alloys are readily available. Significant quantities are being imported and sold at prices substantially below our domestic cost of production. This impairs our ability to maintain the facilities required to insure a continuing domestic supply of these essential alloys.

Because we believe that this problem may be of special interest to you, we invite your comments.

Ohio Ferro-Alloys Corporation
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STANDARD FERRO MANGANESE • MEDIUM CARBON FERRO MANGANESE • SILICO-MANGANESE • MANGANESE SULFIDE
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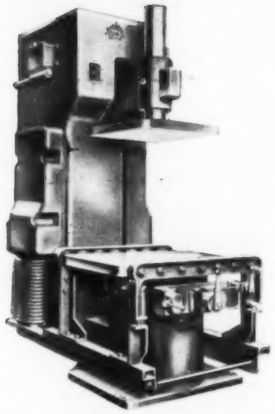
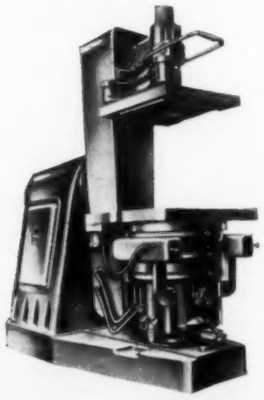
AS SHOWN AT CLEVELAND



BQ

New Push Button shockless jolt squeeze machine. Produces cope and drag in 10 seconds. Completely automatic. See it at the A.F.S. Show.



BT

These Turnover type Moulding Machines are doing a good job in foundries all over the U.S.A. and Canada. Automatic Timer, Automatic Anvil, Automatic Mould Removal.

BRITISH MOULDING MACHINE CO LTD
FAVERSHAM KENT
ENGLAND

P1452

Circle No. 220, Page 7-8

have you read . . . ?

Gitzen, J. A., **Progress in the Development and Utilization of Additives in the Foundry Industry.** Delta Oil Products Co., Milwaukee, 1957, 37 pp.

Explains the use of the following as core and sand binders: sea coal, sea coal substitutes, linseed oil, polymerized resins, pitch, rosin, western bentonite, calcium lignin, wood flour, plastic resins and fast drying oils.

Frede, L., **Manual for Moulders,** (in German), 2nd ed., Verlag Julius Beltz, Weinheim A. D. Bergstr., Germany, 1957, 167 pp., DM 8.50 ($2.15).

Serves as a model for a training manual with an abundance of textbook illustrations. Initial chapters go in to the physics and chemistry of molding.

Atlas Metallographique de Microstructures Types, Editions Techniques des Industries de la Fonderie, Paris, 1957.

A portfolio of microstructure photography. Serves also as an album of defects in metal structure.

Campbell, T., **The Iron and Steel Industry. Vocational and Professional Monographs,** Bellman, Cambridge, Massachusetts, 1957, 40 pp.

One of a series in the Vocational and Professional Monograph Series, used in connection with guidance activities or counseling in the choice of a career. Tells of the history of the occupation or industry, qualifications for employment, training required, methods of entry, opportunities for advancement, earnings, general trends and sources of further information.

Barnes, R. M., **Work Sampling,** 2nd ed., Wiley, New York, 1957, 283 pp.

An intensive application of statistics to time and motion study. Many charts, tables, and illustrated formulae serve as a guide for industrial engineering sampling techniques and control of men and machines.

Schelleng, R. D. and J. T. Eash, **Effect of Composition on the Elevated Temperatures Properties of Ductile Iron.** International Nickel Research Laboratory, Bayonne, N. J., 1957.

The paper presented before A.S. T.M. June 19, 1957 tells of the effects of variations in phosphorus, copper and molybnenum contents and heat treatment on the creep resistance of ferritic and pearlitic ductile iron at 800 F. Also, data on tensile strength, stress rupture and creep properties of

M. HOLTZMAN METAL CO.

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GUARANTEED Brass, Bronze and ALUMINUM INGOT to your specifications IMPROVED WITH FACTOR "X"!

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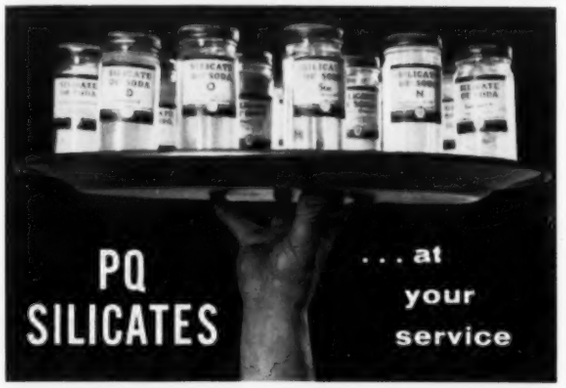
Circle No. 221, Page 7-8



Whatever your foundry use for sodium silicate is, the right one for you is found in the PQ line. This covers 40 products (liquids, solids, hydrated and anhydrous powders), $2Na_2O:SiO_2$ to $Na_2O:3.75SiO_2$.

Maintaining quality control in your operations is easier. Both raw materials and finished silicates are carefully checked so that dependable quality is uniform, shipment after shipment.

PQ silicates have been made for a century. Helpful data on silicates and their uses are available in PQ bulletins. Request information on your silicate use.

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1125 Public Ledger Building, Philadelphia 6, Pa.

PQ SOLUBLE SILICATES

9 PLANTS • DISTRIBUTORS IN OVER 65 CITIES

Circle No. 222, Page 7-8

nickel-copper ductile iron at temperatures up to 1000 F and of 20-35 per cent nickel austenitic ductile iron at temperatures up to 1000 F and of 20-35 per cent nickel austenitic ductile iron at temperatures to 1200-1400 F.

Safety in Welding and Cutting, American Welding Society, New York, 1958, 49 pp., $2.

A revision of the AWS-ASA Z49 standard. Fire statistics indicate that where this booklet's precautions are heeded, fires do not occur. Emphasis is upon personal protection: eye shielding, health protection through ventilation because of lethal fume formation, as well as medical control and first aid. Covers also the installation, operation and application of gas-welding, arc-welding and resistance welding equipment.

Osborne, A. K., **An Encyclopedia of the Iron and Steel Industry,** Philosophical Library, New York, 1957, $35.

In one volume a concise description of the materials, plant, tools and processes used in the industry, as well as in closely allied fields. The scope is from ore preparation to the finished product. All technical terms used in the book are defined. Although it is a reference book rather than textbook, the specialist will look to it for assistance.

Newell, W. C., **The Casting of Steel,** Philosophical Library, New York, 1957, $35.

Written mainly for steel founders, designers, engineers and metallurgical students. For them it is a guide to all technical aspects of the production of steel castings. Well illustrated.

Thermal Properties of Thirteen Metals, American Society for Testing Materials, Philadelphia, 1958, 30 pp., Special Technical Publication No. 227, $1.25.

Multiple heat transfer problems now current in modern technology give need for this data book. Thermal properties covered are: thermal conductivity, thermal expansion, specific heat and density. Another important thermal property, thermal diffusivity, may be calculated from the known values of thermal conductivity, specific heat and density, mentioned above. Among the thirteen metals, extensive data is supplied for two grades of aluminum, chromium, copper; two grades of inconel, magnesium, molybnenum, monel K; and four grades of steel. Compiled by C. F. Lucks and H. W. Deem.

A. C. Lohse

GUARANTEED
SAVINGS
Now you can change to "SEMI-STEEL" abrasives and get a WRITTEN GUARANTEE from Metal Blast that you'll cut cleaning costs — no matter what steel abrasive you're now using! Reports from foundries using "SEMI-STEEL", plus our own laboratory tests, have convinced us that we can definitely guarantee savings in cleaning costs, over any other steel abrasive on the market.
"SEMI-STEEL" is a newly developed abrasive with steel shot characteristics. It is produced by an entirely new process, so efficiently, that it can be sold at malleable shot prices! "SEMI-STEEL" is manufactured as shot and grit, to S.A.E. specifications. Its performance compares so favorably to that of regular, high grade steel shot that, considering its extremely low price, you can't help but reduce your cleaning costs.
FREE LAB TEST
We invite you to send us a sample of your present steel shot (at least 200 grams). We'll run a test on it, against "SEMI-STEEL", and report the results. Or, we'll gladly send a sample of "SEMI-STEEL" for testing in your own lab. (Give size required.) Either way, you'll get welcome proof of "SEMI-STEEL" savings!
So, why continue paying high prices for steel shot cleaning? Write for more information on "SEMI-STEEL" — send in your sample or request our sample for testing. Take this first step toward savings, right now!
"SEMI-STEEL" SHOT AND GRIT
$155 per ton
in 50 or 100 lb. bags
Beach wear by Jantzen
METAL BLAST, INC.
Circle No. 223, Page 7-8

REPORT ON CASTING TECHNOLOGY

Continued from page 127

pounds, 3) reducing microporosity and 4) slightly reducing grain size. Items 1) and 2) were shown to account for a substantial portion of the property improvement attributable to chilling aluminum-copper castings.

For production of high-strength, high-ductility aluminum-copper castings, iron content should be as low as practicable and solution temperature as high as possible without resulting in casting warpage or partial melting.

Ductile High Strength Titanium Castings by Induction Melting, J. Zotos, P. J. Ahearn and H. M. Green, Rodman Laboratory, Watertown Arsenal, Watertown, Mass.

Melting and casting titanium and titanium-base alloys are difficult because of the metal's extreme reactivity with materials at elevated temperatures. Using a modified induction melting technique, titanium alloy scrap was remelted and processed into castings. Metallurgical evaluation of the castings included chemical analysis, macro and microstructure, and mechanical properties.

These tests indicate that scrap titanium can be reprocessed by induction melting and still exhibit desirable engineering characteristics, making it a useful foundry alloy with mechanical properties approaching specifications for forged titanium.

The induction stirring of the melting furnace produces metal of uniform composition and temperature. Heretofore, such conditions have not existed in the casting of titanium.

Effect of Pressure During Solidification on Microporosity in Aluminum Alloys, S. Z. Uram, M. C. Flemings and H. F. Taylor, Massachusetts Institute of Technology, Cambridge, Mass.

Aluminum alloys 356 and 195 were solidified under pressures varying from atmospheric (15 psi) to 16.7 times atmospheric (250 psi). Pressures greater than atmospheric were found to result in a substantial reduction of microporosity in sand-cast test specimens. Test castings were adequately risered, and alloys thoroughly degassed.

The reduction in porosity effected by greater-than-atmospheric pressure during solidification was found to result in little improvement of mechanical properties in solution treated and aged test bars.

An analysis of the test results indicates that the microporosity in the test specimens studied was probably caused primarily by precipitation of minute amounts of gas during solidification.

Reduction of Silica in Large Shell Molds, L. H. VanVlack, R. G. Wells and W. B. Pierce, University of Michigan, Ann Arbor, Mich.

This paper presents information concerning the nature and extent of SiO_2 reduction at the mold-metal interface. The roles of temperature, casting size, alloys and selected mold materials were investigated in order to interpret the mechanism of the reactions.

When high carbon contents, strong oxide formers, high temperatures or large mold sizes are encountered, SiO_2 will be reduced to SiO by iron in contact with quartz or silicate sand molds.

SiO, even though it is in the form of a gas, does not always escape from the mold cavity and may produce a surface porosity. Lower temperatures permit the dissociation of SiO to SiO_2.

The Effect of Temperature and Atmosphere on Iron-Silica Interface Reaction, G. A. Colligan, L. H. VanVlack, and R. A. Flinn, University of Michigan, Ann Arbor, Mich.

In this investigation, compacts were made of pure iron and quartz sand and subjected to different atmospheres in which the degree of oxidation was controlled by selecting the CO_2/CO ratio. The specimens were examined by microscope and x-ray diffraction.

Data indicate that the mechanism of mold attack in this system is as follows: Iron is oxidized at the mold surface, forming a separate, oxide liquid which wets the silica sand in the mold. This liquid phase penetrates into the pores of the mold. Silica is soluble in this oxide liquid to about 50 weight per cent. Solution of the silica enlarges the pores in the sand.

This enlargement permits the molten iron to penetrate the mold at low pressures although the iron does not wet the silica sand. Depth of penetration into the sand by the iron depends upon the length of time at elevated temperatures and the severity of oxidation.

If the CO_2/CO ratio is maintained at a low level, only quartz grains and iron are present. No iron silicate melt is observed and no penetration occurs at low pressures because the iron does not wet the silica.

Solidification and Risering of Gray Iron Castings, C. M. Adams, Jr., M. C. Flemings and H. F. Taylor, Massachusetts Institute of Technology, Cambridge, Mass.

This paper represents detailed conclusions of an eight-year research program on solidification and risering of gray iron castings.

Natural reduction in volume accompanying the cooling of gray iron is shown to depend on metal chemistry. Size and location of voids are dependent not only on chemistry but also on factors which influence the movement of the casting surface such as:

1) size and shape of the casting;

2) action of atmospheric or ferrostatic pressure.

3) characteristics of the molding material;

4) size, shape, location and thermal treatment of gates and risers.

In many cases the heterogeneous expansion resulting from graphite precipitation accentuates, rather than minimizes, solidification shrinkage.

Plant and Equipment

Prevention by the Ounce, F. J. Dost and G. P. Ribar, Sterling Foundry Co., Wellington, Ohio.

The paper relates specific programs of preventive maintenance concerning electrical equipment, material handling and cranes, melting equipment, fuel burning appliances and compressed air system.

Lubrication, cleaning, and inspection are stressed. Where there exists no hazard of pushing out seals or contaminating electrical insulation or the process, the company's policy is to over-lubricate weekly in the belief that "keeping lube in keeps dirt out." Blow pipes are used to clean electric motors and controllers; air moving impellers, ducts and filters; and cranes, motive units and machines in general. This uncovers most of the locations where failures occur.

These two preventatives lead to about 50 per cent automatic inspection, the cornerstone of successful maintenance.

Preventive program for plant electrical equipment centers about a file containing an individual card for every electrical item. Complementary files hold parts lists; installation, operating and adjusting instructions; and wiring diagrams.

Establishing An Effective Preventive Maintenance Program, W. Huelsen, Caterpillar Tractor Co., Peoria, Ill.

Huelsen concludes that over-all plant efficiency is best achieved through proper relationship between maintenance and engineering functions:

1) The foundry manager has the responsibility to make sure that planning and production departments get the engineering and maintenance services they need.

2) The foundry engineer should provide maintenance service to each shift and also should give the maintenance department the technical assistance it needs.

3) The general maintenance supervisor has charge of all three shifts in the maintenance department. He should see to it that each shift supervisor provides for the needs of both the preceding and succeeding shifts, thus assuring continuity of operation.

4) Each shift maintenance supervisor must thoroughly understand the needs, capabilities and problems of the other two shifts. Foremen should be rotated from the first, to the second, to the third and back to the first shift. If two or more foremen for each shift, rotate half in one order, and half in the other. Shift rotation gives each foreman a greater perspective of problems involved and minimizes "passing the buck."

AFS PUBLICATIONS

If you are a newcomer to the field of metalcastings, you can find a road to success in the knowledge available to you in the authoritative publications of the American Foundrymen's Society.

The usefulness of these books is not limited to the new student. Whatever your position in the industry, you daily encounter problems the answers to which are spelled out in one of the publications listed below.

Please note that two prices are given in this partial list of AFS publications: a member price and a non-member price.

PRICE IN BOLD IS FOR AFS MEMBERS

FERROUS PRACTICE

ALLOY CAST IRONS HANDBOOK
$2.75 or $4.50
THE CUPOLA AND ITS OPERATION
6.00 or 9.50
ENGINEERING PROPERTIES OF CAST IRON
2.25 or 3.50
RECOMMENDED NAMES FOR GATES AND RISERS
0.25 or 0.40
ANNOTATED BIBLIOGRAPHY OF CUPOLA OPERATIONS
2.00 or 4.00
GRAPHITE CLASSIFICATION CHART (25 x 38 in.)
1.25 or 1.75
RECOMMENDED NAMES FOR GATES AND RISERS (17 x 28-in. chart)
0.25 or 0.40

Research Reports

RISERING OF GRAY IRON CASTINGS—REPORT NO. 2
1.00 or 2.00
RISERING OF GRAY IRON CASTINGS—REPORT NO. 4
0.35 or 0.55
RISERING OF GRAY IRON CASTINGS—REPORT NO. 5
0.35 or 0.55
STEEL SANDS AT ELEVATED TEMPERATURES (Twelfth)
0.40 or 0.60

NON-FERROUS PRACTICE

CAST BRONZE A.S.M.

modern castings

FOUNDRY FACTS NOTEBOOK

FUNDAMENTALS OF MOLDING

by A. D. Barczak
Superior Foundry, Inc.
Cleveland

Foundry Facts Notebook is designed to bring you practical down-to-earth information about a variety of basic foundry operations. As the name implies, this page is prepared for easy removal and insertion into a notebook for handy future reference.—Editor

Castings are produced by pouring molten metal into refractory molds and allowing the metal to solidify. Fundamentally, a mold is made by shaping a suitable plastic material into the desired form so that when a liquid metal is introduced into the cavity, the solidified metal will retain the shape of the mold cavity and can be separated from the material of which the mold is formed.

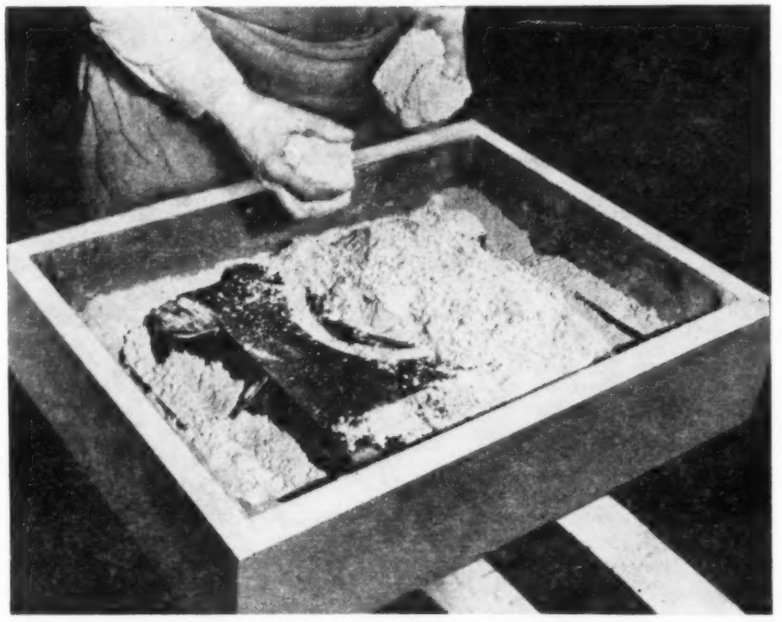
The molder's ability to make a mold is the basic skill of the foundry. He must know how to prepare molds with the following characteristics:

1) Strong enough in construction to sustain the weight of the metal.
2) Made of materials refractory enough to withstand high temperatures of the metal and cleanly strip away from the casting after cooling.
3) Made of materials with a low gas content.
4) So constructed that any gases formed can pass away through the body of the mold itself rather than penetrate metal.
5) Adequate resistance to the cutting action of the rapidly moving metal during pouring.
6) Collapsible enough to permit the casting to contract in normal amounts after solidifying.

The refractory material normally used by commercial foundries is silica sand bonded by nature with natural clay and known as a natural molding sand; or bonded with highly concentrated clays through the use of sand mixers and termed synthetic molding sand.

Molding Tools

Flasks are boxes of wood or metal in which the mold is made. The sections of a completed mold are known as: 1) cope, or top section. 2) drag, or bottom section 3) cheek, or middle section, when more than two sections are required.



Facing sand is used to produce a smooth casting surface.

The basic tools used by the molder may be described as follows:

The RIDDLE is used for sifting the sand over the surfaces of the pattern when starting a mold.

RAMMERS, used for tamping the sand around the pattern in the flask, are for the heavier class of casting made of iron, although sometimes they have a wooden handle with a cast-iron butt on one end and a cast-iron peen on the other.

The STRIKE is used to scrape the extra sand from the top of the cope or drag and also for leveling the loose sand placed on the bottom of the larger drags before positioning the bottom-board.

CLAMPS are used for holding together the cope and drag of the completed mold or for clamping together the mold-board and the bottom-board on either side of the drag when the latter is rolled over.

The BELLOWS is used to blow parting sand from the pattern and also blow loose sand and dirt from the mold cavity.

GAGGERS or HOOKS are L or S shaped pieces of wrought or cast-iron or steel. They are used to hold up deep projections of sand which, if unsupported, would fall of their own weight.

TROWELS are of many different styles and sizes to suit the individual taste of the molder and the particular requirements of the job. The trowel is used for making the joints and for finishing, smoothing and slicking the flat surfaces of the mold.

VENT-WIRES are steel wires, slightly enlarged at one end and having a handle on the other. They are used to perforate the mold to permit easy escape of gases when the casting is poured.

A BOSH or SWAB is made of

FUNDAMENTALS OF MOLDING

The molder's ability is the basic skill in metalcasting practice.

Molding floor with most of the basic tools of the molder in use.

hemp, tasseled to a point at one end and bound with twine at the other to hold it together. It is used for placing a small amount of water on the sand around the edge of the pattern before the pattern is rapped for drawing from the mold.

DRAW SCREWS are eye-bolts threaded on one end. They are used for drawing large wooden patterns from the sand by screwing into holes left for that purpose in the pattern.

The GATE CUTTER is a piece of sheet brass bent to a semi-circle on one edge. It is used to cut the ingate in the drag leading from the hole left by the sprue-stick to the mold.

There are also many auxiliary tools such as: LIFTERS, SLICKERS, DOUBLE ENDERS, and CALIPERS.

Molding Materials

The basic materials which a molder must handle are few. There are an infinite number of variations but the fundamentals of their use are the same.

Normally, two types of sand are used in the foundry, referred to as dry sand and green sand. The fundamental difference is that green-sand molds are poured any time after making without further conditioning, while dry-sand molds are baked in an oven or dried with a torch. When a torch is used the molds are termed "skin dried".

In many cases green-sand molds have been found essential for making castings of intricate design in great quantities. The resistance of dry-sand molds and cores to the solid contraction of the metal frequently prohibits their use where light and intricate castings are produced. Green sand gives less resistance to the normal contraction of the casting than does dry sand, and consequently severe strains which cause hot tears or cracks are often avoided.

Facing nails are used (1) to reinforce mold surfaces and prevent erosion of the mold face, (2) to mechanically lock the sand on the face with the sand behind it and (3) to act as a means of slightly accelerating solidification at internal corners of the casting.

Chaplets are metal supports used to hold a core in place in the mold when core prints are inadequate.

Internal chills are used to accelerate solidification of molten metal in certain heavy sections of castings to promote directional soidification.

External chills are metal parts shaped to fit the surface of certain sections of castings and serve to promote solidification by rapidly extracting heat from the metal.

Flasks must be sufficiently rigid so that distortion does not occur during ramming or handling and so that they will resist the pressure of the metal during casting. The pin fittings and pins should be continually checked for wear to avoid mismatched, or shifted molds. The use of steel flasks is preferred; however, many foundries employ successfully wooden snap and slip flasks, metal pop-off flasks with cast iron jackets and wooden snap flasks with bands.

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foundry trade news

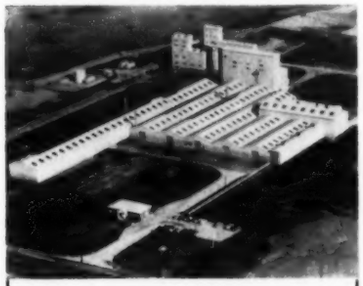
Continued from page 131

an index of 100. Figures also indicate February bookings represent 12.5 per cent of total bookings reported in 1957 and 15.55 per cent of same month in 1954, (the base statistical year).

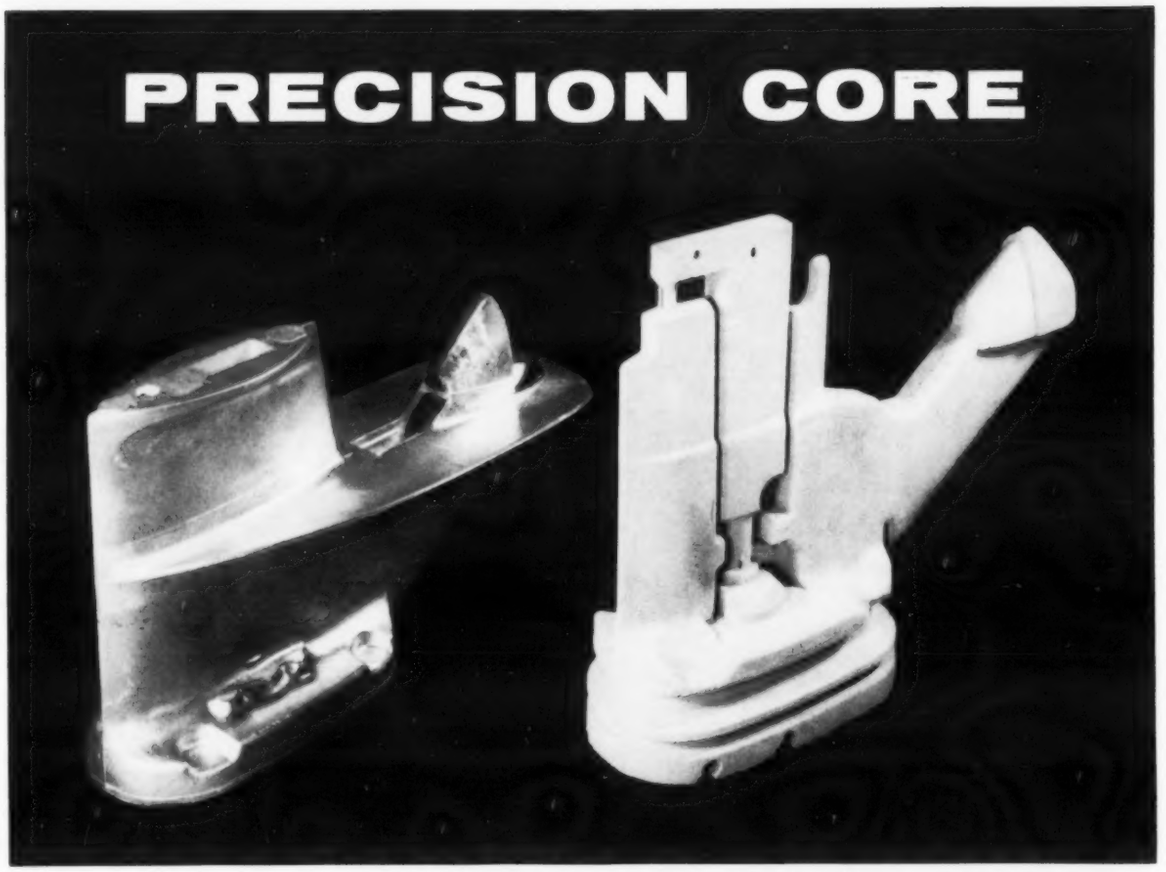
"The chance for a Spring upturn in materials handling industry now appears brighter than it has in the past two months," according to R. L. Fairbanks, president of the Institute and vice-president of Towmotor Corp., Cleveland.

Several industry leaders point out this slight upturn is an indication that falling business conditions in this industry have leveled off and dollar volume of orders for first quarter of 1958 is expected to hold about the same as final quarter of 1957, with steady increases during the second and third quarters.

Birdsboro Steel Foundry . . . Philadelphia, recorded record sales and earnings in 1957 and is expecting further increases in sales and income this year. Their cost reduction is being increased through continued mechanization.



Harbison-Walker Refractories Co. . . . Pittsburgh, Pa., announced the addition of a new basic refractories plant at Hammond, Ind., which will manufacture high alumina brick, superduty silica brick and basic brick. The new building is designed to give natural illumination and is equipped with all facilities for the manufacture of refractories in small tonnage lots, including all steps of crushing, grinding, sizing, blending, forming, drying and firing. This site was chosen because of proximity to raw materials and the expanding Chicago and Midwest market areas. One of the newer developments in operation encloses individual bricks in a welded steel case.



Casting and core for upper gear housing of outboard motor.

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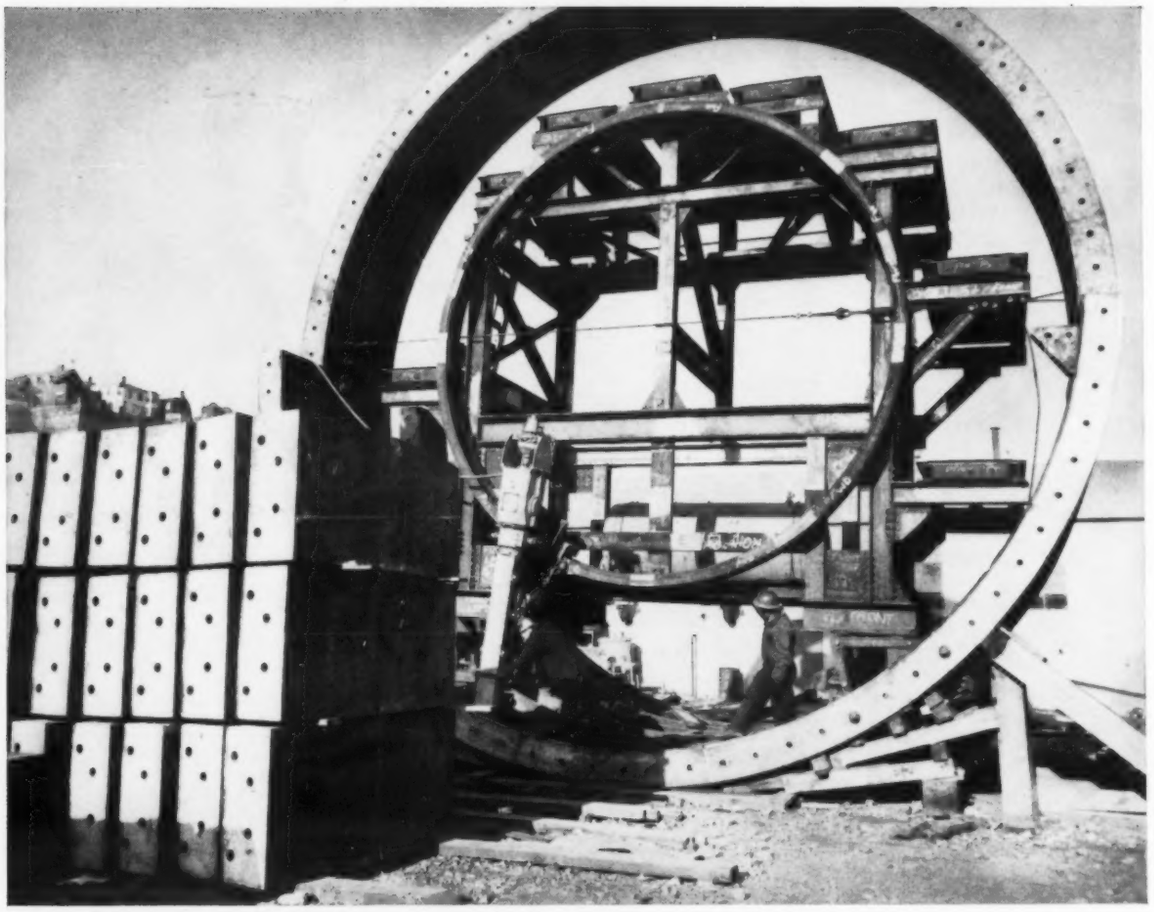

CASTINGS TO KEEP TRAFFIC MOVING SMOOTHLY—Giant castings, such as these used in highway tunnels, are another example of how the foundry industry contributes to progress.

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Circle No. 233, Page 7-8

Melting for

■ By way of introduction, it should be mentioned that the data to be presented are based largely on experiences in the Investment Casting Foundry, General Electric Co., a captive operation producing castings on a limited production basis. Melting equipment used for this work included a 3-1/2 lb and 10 lb indirect carbon arc furnace and a 100 KW induction melting unit with furnaces of 50-lb, 100-lb and 200-lb capacity.

With the arc furnace, pressures up to 30 psi can be applied on the melt during pour. This unique feature gives a better chance for success in filling out very thin sectioned castings than would be possible in a gravity-pour induction heat. Fill problems can sometimes be eliminated in induction heats by use of a vacuum pouring stand.

One of the most serious disadvantages of the arc pot is the limited capacity. Although yields are high because pouring is done under pressure, 5 or 6 lb of castings are the maximum that could be expected from a 10-lb unit. With induction melting there are practically no weight limits.

The arc pot also has some limitations from the alloy standpoint. Carbon pick-up is a problem in low-carbon alloys. However, since it is possible to use a protective atmosphere during melt down and pour, the arc pot gives excellent results, surfacewise, with alloys containing high titanium and aluminum.

Cost

A 100 KW induction unit, on a production basis, is capable of melting about 1200 lb of metal per day. To pour a heat of investment molds, a five-man pouring crew is used. However, four of these men perform other assignments between pours requiring about 50 per cent of their time. This gives about 400 lb per man per day. One man can operate two 10-lb arc furnaces and can pour about forty 10-lb heats per day. So labor time for melting is practically the same. However, since induction melting has no weight restriction, fewer molds can be processed with more castings per mold. With carbon arc melting all heats are made from remelt stock. With induction melting, foundry returns can be remelted with considerable savings in material costs.

Installation, maintenance and repair costs are much lower for arc furnaces than for induction units.

Close control of melting practice is a must to meet some of the properties

by L. J. DiNuzzo
General Electric Co.
Schenectady, N.Y.

now being written into specifications. Since the arc furnace uses remelt stock, casting composition depends to a degree on the charge. However, because of overheating tendency and poor temperature control in small heats, there will probably be a deviation in composition from melt to melt, although the same master heat is used.

Melt Control

Where close control of composition is important, the 100-lb or 200-lb induction heat has a decided advantage over the 10-lb arc pot heat. Because of heat size, an analysis for each heat can be justified.

Grain size control is also a problem in arc melting. The best way to control grain size in a given alloy is by control of pouring temperature. In induction melting practice, use of immersion thermocouples permit good temperature control.

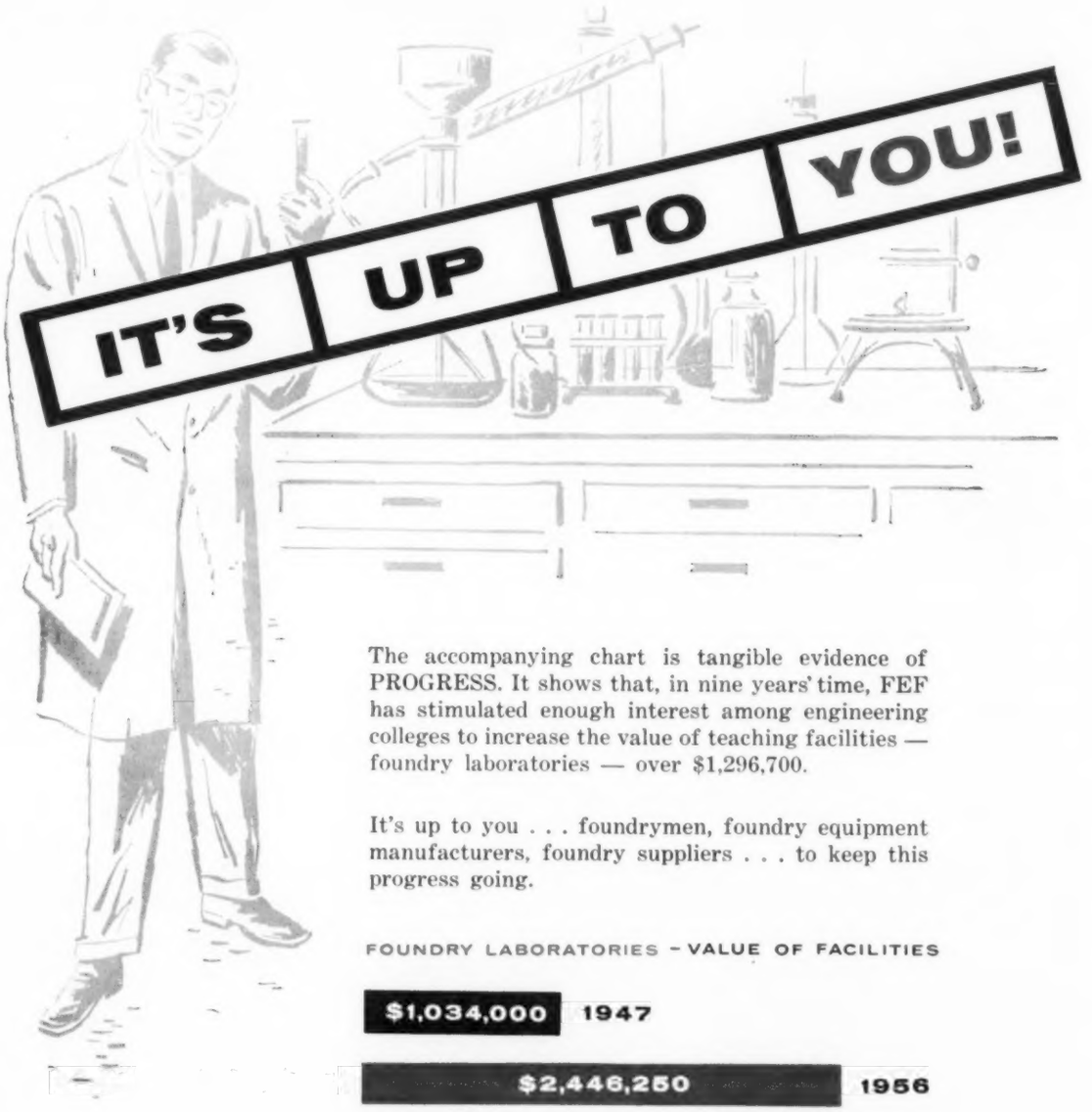
With the arc furnace, optical or pyrometer readings may be in error because of the time interval between the reading and pour or because of oxide or slag blankets on the melt.

Induction melting also provides the investment caster an opportunity to diversify his activities since it can be used for new processes such as Glascast, Investment X, shell molding, Shaw Process, etc. with a minimum of investment for equipment. Of these new techniques and processes, the only one that can be used with the arc furnace is Glascast.

The investment caster who pours 100-lb and 200-lb induction melted heats has the following advantages to offer the buyer interested in high quality high-alloy castings:

1) Close chemical control—also, his analyses are the chemistry of the casting, not of the charge.
2) Close temperature control and therefore grain size control.
3) Close control over gas content, especially oxygen and nitrogen.
4) Control over melt history, i.e., materials used, amount of superheat, order of melting, etc.
5) Control over deoxidation.

■ Condensed from a talk presented at the 5th Annual Meeting of the Investment Casting Institute.



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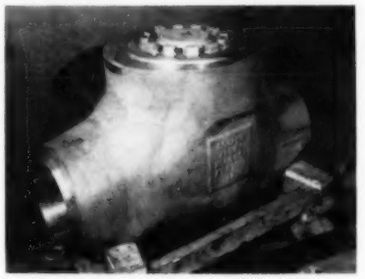
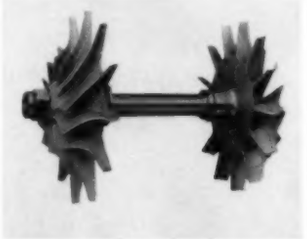


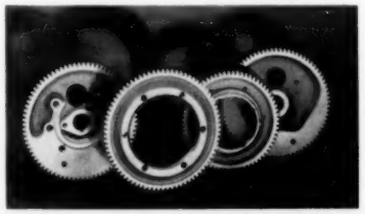
centerline shrinkage, the design incorporates a tapered rather than a uniform section. In the tapered section, the metal in the thinnest section freezes first. The last metal to freeze is the thick section at the riser.

. . . **Haynes Stellite Co.,** Kokomo, Ind., produces a turbine wheel with 0.040-in. thick vanes that need no



machining. Wheel is made by investment casting in Haynes Stellite alloy No. 31. Wheel operates at 1450 F and 42,000 rpm in turposupercharger made by Schwitzer-Cummins Co.

. . . **Central Foundry Division,** GM, casts a gear that replaces a forged part and eliminates a heat treating



operation. Gears for power train of diesel engines are cast in newly developed 88M ArmaSteel, a pearlitic malleable iron.

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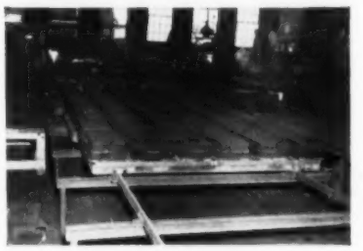

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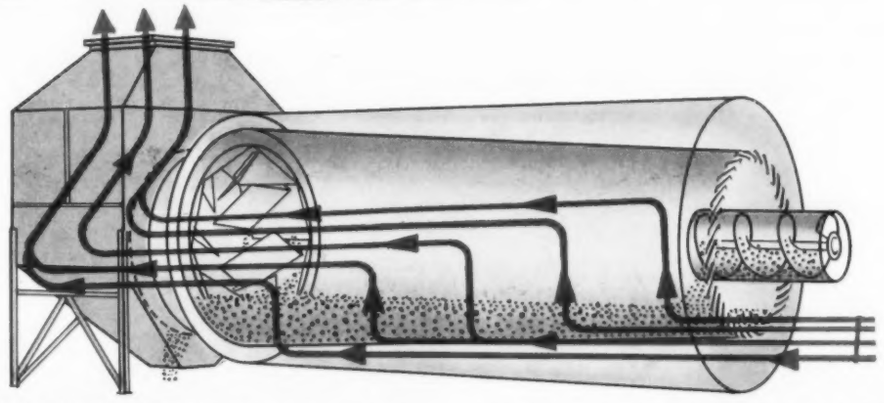

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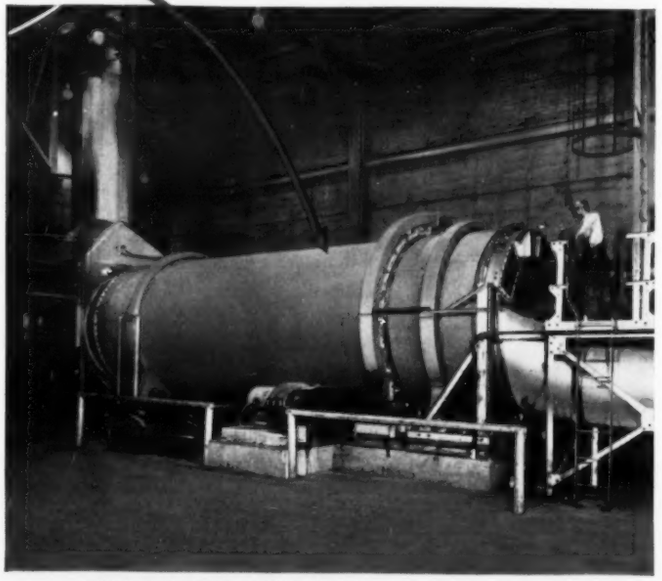
Get all the facts from your nearby Link-Belt office. Or write for your copy of Book 2423 on Foundry Equipment . . . or Book 2511 featuring Roto-Louvre Dryers.



DRYING UP TO 35 TPH OF SAND, a large midwest foundry installed this Link-Belt Roto-Louvre dryer to provide additional sand capacity for increased production demands. In addition to low-cost efficiency, Roto-Louvre dryers minimize maintenance. Slow speed and the fact that sand rolls over itself, instead of sliding on metal parts, reduces wear.

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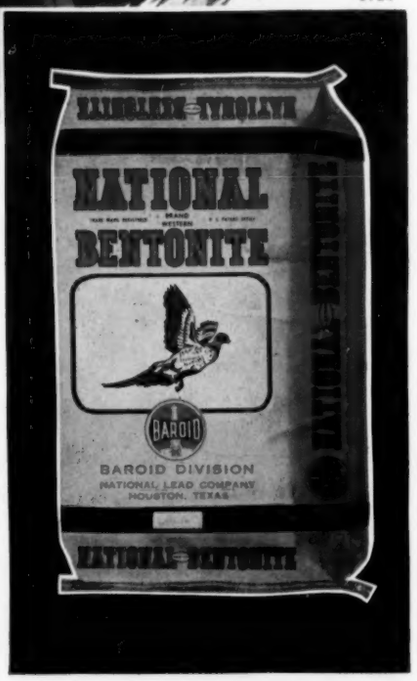

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